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DUMONT MODEL 401 CATHODE RAY

OSCILLOGRAPH

401/401R

4½

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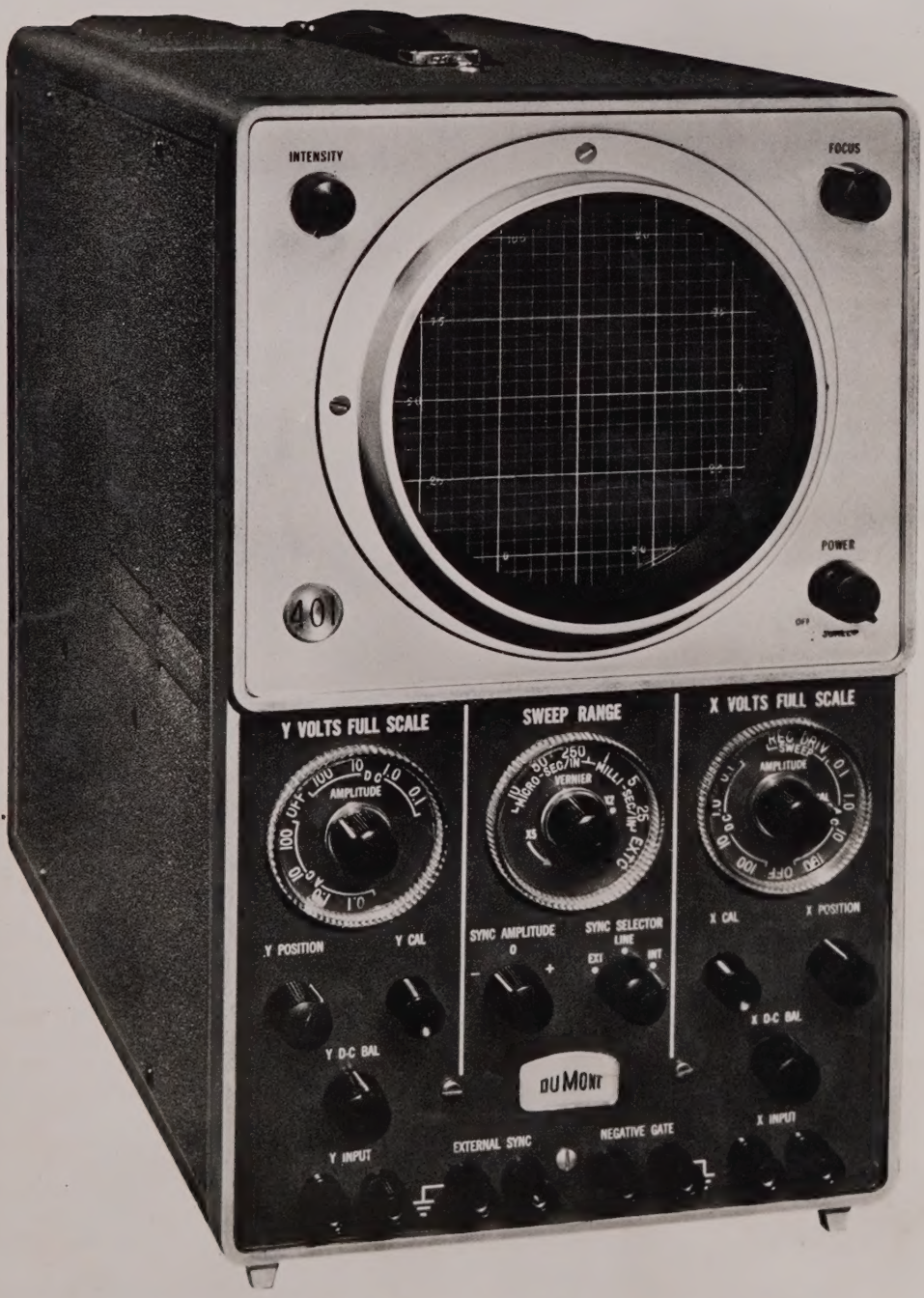

Figure 1-1. Du Mont Type 401 Cathode-ray Oscillograph

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SECTION 1
TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instructions covers information on both the Type 401 (bench model) and Type 401-R (rack mounted) Cathode-ray Oscillographs. Electrically, the two types are identical; mechanically, they differ in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 401 pertain also to the Type 401-R.

1-2. PURPOSE

The Du Mont Type 401 Cathode-ray Oscillograph is a quantitative instrument designed to be used for almost any general application. The high gain of this instrument assures that it can be used directly with many types of transducers, while dc amplification provides that the lowest frequency portions of signals will be faithfully reproduced.

1-3. FEATURES

- A 5ADP- cathode-ray tube with 3000 volts over-all accelerating potential
- Provisions for balanced or single-ended vertical and horizontal input signals
- Identical frequency response and gain of both X and Y amplifiers extending from dc to 30% down at 150 kc
- Calibration voltage of 0.1 volt peak-to-peak, ±2%, is provided for each amplifier independently.
- Calibrated linear sweep, writing rates from 25 milliseconds to 10 microseconds per inch in six steps, with multipliers of 1, 2 and 5
- Uncalibrated linear sweep, continuously variable in writing rate from 125 milliseconds to 10 microseconds per inch
- Provision for connection of external capacitance provided at rear of instrument for extension of sweep time
- Driven or recurrent sweep operation with automatic forward trace brightening
- Examination on the screen of any portion of signal expanded up to at least three times full scale without distortion
- Provision for Z-axis (intensity) modulation
- Provision for direct access to the deflection plates of the cathode-ray tube
- Regulated high-voltage supply
- Internally regulated transformer provided to achieve nearly complete freedom from line-voltage changes
- Printed wiring and simple, easily accessible layout is employed

1-4. TECHNICAL SUMMARY

The electrical and physical characteristics of the Types 401 and 401-R are listed in Table 1-1 which follows.

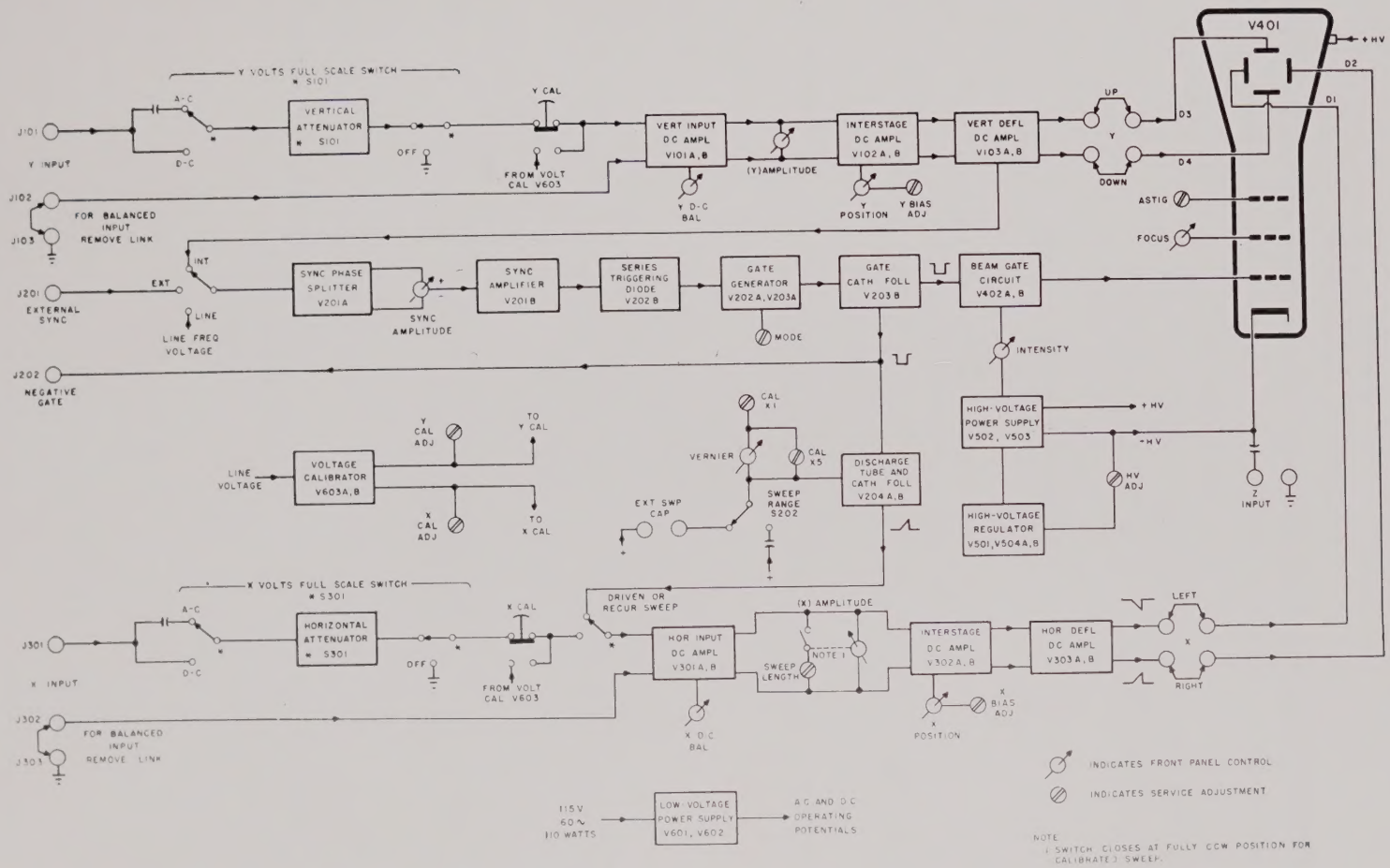


Figure 1-2. Over-all Functional Block Diagram, Types 401 and 401-R Cathode-ray Oscillograph

TABLE 1-1
TECHNICAL SUMMARY
DU MONT TYPES 401 AND 401-R CATHODE-RAY OSCILLOGRAPHS

CATHODE-RAY TUBE

1-1. TYPE	5ADP— operated at a total accelerating potential of approximately 3000 volts
1-2. CRT SCALE	Engraved edge-lit scale and appropriate color filter over face of tube. Dimmer control varies illumination level from zero to intensity adequate for photographic recording

VERTICAL DEFLECTION AMPLIFIER

2-1. INPUT COUPLING	
a. Single-ended signal	Direct or through capacitor of 600-volt rating to amplifier
b. Balanced Signal	Available at 0.1 DC position of Y VOLTS FULL SCALE switch
c. Direct to Deflection Plates	Provision is made for dc connection to the deflection plates. For best focus, an average dc potential of 280 volts with respect to ground should be maintained
d. Maximum Permissible Signal	600 volts (sum of signal + dc)
2-2. INPUT ATTENUATION	Provided by a frequency compensated attenuator with steps corresponding to full scale voltages of 0.1, 1.0, 10, and 100 volts ±2%; OFF position is provided
2-3. INPUT IMPEDANCE	
a. Through Amplifier	
(1) Single-ended	2 megohms, 55 μμf maximum
(2) Balanced	2 megohms, 55 μμf maximum each side to ground
b. Direct to Deflection Plates	
(1) Single-ended	No greater than 5 megohms (Deflection plate return resistors are not supplied)
(2) Balanced	No greater than 10 megohms center-tapped to ground (Deflection plate return resistors are not supplied)
2-4. SINUSODIAL FREQUENCY RESPONSE (Referred to sensitivity at 1 kc)	
a. High Frequency	Down not more than 30% at 150 kc ±15 kc. Response at 100 kc may vary up to 5% with variations in AMPLITUDE control setting; relatively no change when using the AMPLITUDE control from midway to maximum setting
b. Low Frequency	
(1) Direct coupled	Flat to dc
(2) Capacitively coupled	Down not more than 10% at 2 cycles
2-5. PULSE RESPONSE (to a step function)	
a. Rise Time	2.4 microseconds or less
b. Overshoot	2% or less
c. Decay at top	
(1) Direct coupled	None
(2) Capacitively coupled	10% in 20 milliseconds nominal
2-6. DEFLECTION SENSITIVITY	
a. Through Amplifier (at full gain)	0.02 peak-to-peak volt inch nominal ±10%
b. Direct to Deflection Plates	31.5 to 38.5 peak-to-peak volts/inch

TABLE 1-1. TECHNICAL SUMMARY (Continued)

2-7. EXPANSION AND POSITIONING	Any portion of three times full scale deflection can be positioned on screen. Undistorted deflection is available over the visible portion of the trace at any position-control setting, provided that the AMPLITUDE control is advanced more than 20% from its minimum position. For AMPLITUDE control settings of less than 20%, undistorted deflection is limited to approximately twice full screen
2-8. LINEARITY OF ON-SCREEN DISPLAY	Any 10% increment is within 10% of any other 10% increment within the 4-inch full scale limit
2-9. COMMON MODE	
a. Common Mode Rejection	Approximately 400 to 1 at maximum (Y) AMPLITUDE setting. (Y DC BAL and Y POSITION controls adjusted for maximum common mode rejection ratio)
b. Maximum Common Mode Signal	0.3 volt minus peak amplitude of observed signal
c. Maximum Grid-to-grid Signal	3 volts peak-to-peak minus peak amplitude of common mode signal
2-10. STABILITY	
a. Varying Line Voltage (±10%)	Drift does not exceed a total of 1 inch (plus and/or minus ½ inch from screen center) in an 8-hour period
b. Constant Line Voltage	Drift does not exceed a total of ½ inch

HORIZONTAL DEFLECTION AMPLIFIER

(Identical to vertical deflection amplifier except as shown)

3-1. DEFLECTION SENSITIVITY	
a. Through Amplifier (at full gain)	0.025 peak-to-peak volt/inch nominal ±10%
b. Direct to Deflection Plates	40 to 50 peak-to-peak volts/inch
3-2. BEAM GATE	Automatic beam brightening during forward sweep. Beam is not visible during sweep retrace or while sweep is at rest. INTENSITY control overrides blanking for X-amplifier use The beam gate may be used to gate the beam on for a time interval determined by the SWEEP RANGE and VERNIER controls when the X amplifier is being used
3-3. X & Y AMPLIFIER RELATIVE PHASE SHIFT CHARACTERISTICS	
a. Any Combination of (X) & (Y) AMPLITUDE Settings	Phase shift does not exceed 6 below 150 kc and 2 below 50 kc
b. (X) & (Y) AMPLITUDE Set For Minimum Relative Phase Shift at 150 kc	Phase shift does not exceed 1 below 150 kc

AMPLITUDE CALIBRATION CIRCUIT

4-1. VOLTAGE CALIBRATOR	
a. Waveshape and Frequency	Clipped sine wave at power-line frequency
b. Amplitude	0.1 volt peak-to-peak ±2% is provided for each amplifier independently
c. Availability	By means of the X CAL or Y CAL push-push switch which automatically disconnects the input from the amplifier and inserts the calibration signal. X calibrator is inoperative when DRIVen or RECurrent sweep is in use

TABLE 1-1. TECHNICAL SUMMARY (Continued)

SWEEP CIRCUIT	
5-1. MODE	Vacuum tube sweep, driven or recurrent as desired
5-2. SWEEP WRITING RATE	
a. Internal	
(1) Calibrated	From 25 milliseconds to 10 microseconds per inch in six steps, with multipliers of 1, 2, and 5
(2) Uncalibrated	Continuously variable from 125 milliseconds to 10 microseconds per inch
(3) Accuracy	±8% of specified writing rate per inch
b. External	EXT SWP CAP terminals are provided (rear panel) for slower sweeps. See Section 2, Operation, for further details
5-3. SWEEP EXPANSION	16 or more inches
5-4. HORIZONTAL POSITIONING	Sufficient to position any full scale portion of the expanded sweep (16 inches) or X INPUT signal on the screen
5-5. BEAM GATE	See 3-2
5-6. NEGATIVE SWEEP GATE OUTPUT	Direct coupled negative sweep gate signal of approximately 5 volts amplitude available at NEG GATE front-panel terminal. The dc level of this signal is approximately +30 volts
SYNC CIRCUIT	
6-1. SYNC SOURCE	Positive or negative INTernal, power LINE, or EXTernal signals
6-2. SNYC SENSITIVITIES	
a. Driven Sweep Can be Triggered by Signals Having the Following Characteristics:	
(1) Rate of rise	
EXT	80 volts/second minimum
INT	5 inches/second minimum
(2) Duration	0.2 microsecond minimum
(3) Amplitude	
EXT	2.5 volts peak-to-peak minimum
INT	0.4 inch of vertical deflection minimum
(4) Sinusoidal signal	Sine waves from 10 cps to 100 kc with a minimum peak-to-peak voltage of less than 2.5 volts (EXT), 0.4 inch of vertical deflection (INT), and from 2 cps to 250 kc with larger amplitude
b. Recurrent Sweep	Recurrent sweep can be synchronized to 500 kc with a signal amplitude of 4 volts peak-to-peak minimum (EXT)
INTENSITY MODULATION CIRCUIT	
7-1. Z AXIS	
a. Availability	Z INPUT terminal is provided on rear panel for signal input. This terminal is returned to ground through a 2.2 megohm resistor
b. Input Impedance	10,000 ohms, 30 μμf minimum
c. Input coupling	Internally the Z-axis signal is coupled through a 0.01 μf capacitor to the cathode of the CRT
d. Polarity	Positive signals decrease beam intensity; 2 to 56 volts peak-to-peak, depending on INTENSITY setting, will blank the beam

TABLE 1-1. TECHNICAL SUMMARY (Continued)

POWER SUPPLY

8-1. POWER REQUIREMENTS
(Includes self-regulating transformer)

a. Primary-power Potential ..... 115 volts ±10%, single phase

*b. Primary-power Frequency ..... 60 cycles

c. Primary Power ..... 110 watts

*A 50-cycle self-regulating transformer and/or an unregulated 50- to 400-cycle transformer are available. The stability figures mentioned in 2-10 do not apply with the unregulated transformer except where the power source is regulated to better than ±1%

8-2. HIGH-VOLTAGE SUPPLY ..... An electronically regulated rf supply system for generating CRT accelerating potentials is provided

8-3. FUSE PROTECTION

a. Primary ..... 2 amperes

b. Secondary

(1) LV Power Supply ..... 0.15 ampere, slow blow

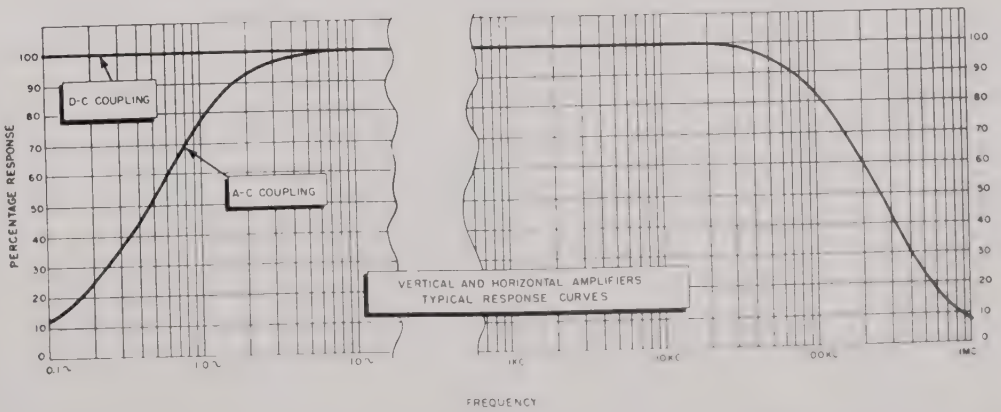
(2) Heaters ..... 8 amperes

TUBE COMPLEMENT

1 – OA2	1 – 5642	3 – 6U8
1 – 1X2-A	1 – 6AL5	1 – 12AT7
1 – 5ADP–	1 – 6AQ5	5 – 12AU7
1 – 5V4-G	2 – 6BK7–A	1 – 12AX7

PHYSICAL CHARACTERISTICS

	TYPE 401	TYPE 401-R
Height	15 inches	8¾ inches
Width	8¾ inches	19 inches
Depth	20⅜ inches	19 inches (measured from rear of front panel to rear end of instrument)
Weight	Approximately 45 pounds	



SECTION 2
OPERATION

2-1. GENERAL

The Du Mont Types 401 and 401-R Cathode-ray Oscillographs are shipped with all tubes in place and ready to operate.

Since these instruments are portable, no special installation procedure is required. The –R model has a front panel 19 inches wide by 8¾ inches high for mounting the instrument in a standard relay rack or cabinet.

Normally the Type 401 or 401-R may be placed where most convenient for viewing while at the same time maintaining short signal leads. Although shielding has been provided, operation in very strong magnetic fields may cause spurious deflections and should be avoided. Reorientation or additional shielding of the instrument may be necessary to minimize the effects of such fields.

*The power transformers in these instruments are intended for operation from a 100—130-volt 60-cycle power source only. A variation of 1% in the line frequency will change the secondary voltages delivered by the transformer by about 2%.

* Except on special order for other frequencies.

2-2. FRONT AND REAR-PANEL FACILITIES

The front and rear-panel markings are essentially self explanatory, and after carefully studying Table 2-1, the operator will find it possible to master the controls with a minimum of practice.

2-3. PRECAUTION AGAINST SCREEN BURNING

A sharply focused spot of high intensity and small area should not be permitted to remain stationary on the screen for any length of time. Under such conditions, the entire beam energy is concentrated over a small area, thus subjecting the screen material to burning and discoloration. This condition is most likely to exist when using the driven mode of sweep operation, with the INTENSITY turned up, and no signal input.

2-4. ENERGIZING THE EQUIPMENT

To place the instrument in operation, plug the power cord into the proper power source and rotate the SCALE control clockwise. See Item 8-1 in Table 1-1, for Power Requirements. Allow approximately one minute for the instrument to warm up; in the

TABLE 2-1
FRONT AND REAR-PANEL FACILITIES

NAME	FUNCTION
FRONT-PANEL FACILITIES	
INTENSITY	Control: varies the trace brightness. See paragraph 2-8d in reference to Gated-beam Operation
FOCUS	Control: adjusts the trace sharpness
Y POSITION	Control: positions the trace vertically
X POSITION	Control: positions the trace horizontally
X DC BAL	Control: when properly adjusted, prevents horizontal movement of the trace when the (X) AMPLITUDE control is varied
Y DC BAL	Control: when properly adjusted, prevents vertical movement of the trace when the (Y) AMPLITUDE control is varied
X CAL	Push-push switch: provides 0.1 volt peak-to-peak calibration signal to horizontal amplifier input
Y CAL	Push-push switch: provides 0.1 volt peak-to-peak calibration signal to vertical amplifier input
SYNC SELECTOR	Control: selects source of sweep synchronizing signals (EXT, LINE and INT)
SYNC AMPLITUDE	Control: selects polarity and adjusts the amplitude of sweep synchronizing signals

TABLE 2-1. FRONT AND REAR-PANEL FACILITIES (Continued)

NAME	FUNCTION
FRONT-PANEL FACILITIES	
Y VOLTS FULL SCALE	Concentric controls: Outer knob provides for the direct full scale reading of the input signal in steps of 0.1, 1.0, 10, and 100 volts peak-to-peak for both capacitive or direct inputs when vertical amplifier is properly calibrated (see 2-7e) for calibration procedure; grounds the input stage of the vertical amplifier in the OFF position
(Y) AMPLITUDE	Inner knob provides continuous amplitude variation of vertical deflection
X VOLTS FULL SCALE	Concentric controls: Outer knob same as Y VOLTS FULL SCALE except that X INPUT signals are applied to the horizontal amplifier and internal signals (DRIVen or RECurrent SWEEP) may be selected. Front-panel markings indicate voltages for full scale deflection (0.1, 1.0, 10 and 100) when horizontal amplifier is properly calibrated. See 2-8e for calibration procedure
(X) AMPLITUDE	Inner knob; control with switch; provides continuous amplitude variation of horizontal deflection (switch not actuated); when set fully CW (CAL SWP), switch is actuated, (X) AMPLITUDE control is inoperative and the instrument can be set for calibrated sweep
SWEEP RANGE	Concentric controls: Outer knob varies sweep writing rates in steps. When (X) AMPLITUDE is set to CAL SWP and VERNIER is set to X1, SWEEP RANGE control provides calibrated sweep rates per knob markings. EXTC (external capacitor) position provides connection of external capacitance for lower sweep writing rates
VERNIER	Inner knob provides continuous variation of sweep writing rates within the limits established by the SWEEP RANGE control. When (X) AMPLITUDE is set fully CW (CAL SWP), VERNIER control multiplies SWEEP RANGE settings by X1 (fully CW), by X5 (fully CCW), and by X2 (white dot)
Y INPUT	Binding posts: connections for external signals to the vertical amplifier, either balanced or single-ended
X INPUT	Binding posts: connections for external signals to the horizontal amplifier, either balanced or single ended, except when X VOLTS FULL SCALE is set at DRIVen or RECurrent SWEEP
EXTERNAL SYNC	Binding posts: provides for connection of external synchronizing signals to the EXT position of the SYNC SELECTOR switch
NEGATIVE GATE	Binding posts: provides a negative gate output for operation of auxiliary equipment
POWER/SCALE	Control with switch: dimmer control varies illumination level of the CRT scale from zero to intensity adequate for photographic recording; switch attached provides means for turning power on and off
REAR-PANEL FACILITIES (Accessible at Rear of Cabinet or Dust Cover)	
EXT SWP CAP	Turret lugs: provides connection for external sweep capacitor when SWEEP RANGE is set to EXTC
X INPUT	Turret lugs: terminals D1 (LEFT) and D2 (RIGHT) provide direct connection of signals to horizontal deflection plates. (The bottom terminals are the output of the horizontal amplifier and are connected by jumpers to the horizontal deflection plate terminals. See paragraph 2-9 for details.)
Y INPUT	Turret lugs: terminals D3 (UP) and D4 (DOWN) provide direct connection of signals to vertical deflection plates. (The bottom terminals are the output of the vertical amplifier and are connected by jumpers to the vertical deflection plate terminals. See paragraph 2-9 for details.)
Z INPUT	Turret lug: provides connection for external signals for intensity modulation of the trace

TABLE 2-2
PRELIMINARY CONTROL SETTINGS

CONTROL	POSITION
Y POSITION, X POSITION, & FOCUS	center of range
INTENSITY	approximately 1/3 CW
Y VOLTS FULL SCALE	OFF
(Y) AMPLITUDE	center of range
SYNC SELECTOR	INT
SYNC AMPLITUDE	fully CCW
X VOLTS FULL SCALE	RECurrent SWEEP
(X) AMPLITUDE	fully CW (CAL SWP)
SWEEP RANGE	5MS/IN
VERNIER	Fully CW (X1)
X CAL, Y CAL	OUT

meantime, set the various controls as indicated in Table 2-2.

2-5. PRELIMINARY ADJUSTMENTS

Center the trace with X POSITION AND Y POSITION controls. If the trace moves as the (Y) AMPLITUDE control is rotated, the Y DC BAL control should be adjusted in the following manner:

Step 1. Make sure that Y SELECTOR is OFF and set (Y) AMPLITUDE fully CCW

Step 2. Center the trace with Y POSITION control

Step 3. Set (Y) AMPLITUDE control fully CW

Step 4. Recenter the trace with Y DC BAL control

Step 5. Repeat steps 1 through 4 until no vertical displacement of the trace is observed while varying the (Y) AMPLITUDE control throughout its range. Note: If satisfactory balance cannot be achieved, see Trouble Shooting Chart, Table 4-3, Item 4-2.

Push in Y CAL and adjust (Y) AMPLITUDE to obtain a vertical deflection of about two inches. Rotate the INTENSITY control clockwise to obtain a pattern having normal brightness and set the FOCUS control for best definition. Next, adjust (X) AMPLITUDE to expand the pattern. If the pattern tends to move off screen, either to the left or right, adjust X DC BAL to position the pattern back on the screen. Finally, adjust SYNC AMPLITUDE and VERNIER controls for a stable pattern about three inches wide.

2-6. OPERATING HINTS FOR THE SWEEP CIRCUIT

a. Driven Sweep

Refer to Technical Summary, Table 1-1, for information on sync sensitivities, and to Table 2-1, for information on Panel controls.

A stable pattern for practically all types of signals can be obtained by using driven sweep; its use is mandatory for viewing random or non-periodic signals or periodic signals of low duty cycle. When operating the instrument in this manner, one sweep occurs for each signal impulse or submultiple thereof. Use of the driven sweep mode of operation, in the majority of applications, is the condition under which optimum performance can be expected of this equipment.

When the oscillograph is set for driven sweep, the spot will be visible only during forward sweep time, provided the INTENSITY control is not set too far clockwise.

Table 2-3 lists the control settings and adjustment procedures for driven sweep operation.

b. Recurrent Sweep

In some applications it is desirable to have the sweep free-running, whether synchronized or not. To achieve this condition proceed as follows: set up the controls as indicated in Table 2-3, except that X VOLTS FULL SCALE is set to RECurrent SWEEP.

One advantage of this mode of operation, is the ability of the sweep to be synchronized to high-frequency repetitive functions beyond that of driven sweep operation. Another advantage is the display of non-synchronous waveforms.

c. Calibrated Sweep

The calibrated sweep writing rates in milliseconds or microseconds per inch is equal to the product of the SWEEP RANGE and VERNIER (set to a designated position) control settings only when the (X) AMPLITUDE control is set fully clockwise to CAL SWP (switch is actuated).

Table 2-4 lists the control settings for calibrated sweep operation. Any other front-panel setting will yield uncalibrated sweep.

d. Extension of Lower Sweep Writing Rates

Provision is made for connecting external capacitors to the EXT SWP CAP terminals (rear panel) to

obtain lower sweep writing rates than provided for in the instrument. For lower sweep writing rates, proceed as follows:

CAUTION

The EXT SWP CAP terminals are approximately 150 volts above ground

Turn off the power and set SWEEP RANGE to EXTC (external capacitor). The extension of the lower sweep writing rates in seconds per inch for each microfarad of external capicitance is: 0.125 second/inch microfarad (VERNIER is set fully clockwise to X1). For example:

Time	External Capacitance
125 milliseconds/inch	1.0 μf
250 milliseconds/inch	2.0 μf
1 second/inch	8.0 μf
5 seconds/inch	40.0 μf

A high-leakage-resistance capacitor (in excess of 100 megohms) of the highest possible quality such as Sprague's styracon B is recommended. Ordinary paper capacitors have high temperature coefficients and poor recovery characteristics. The results will depend entirely on the quality of the component. Tolerance of the capacitor should be ±1% to maintain external calibration equivalent to internal calibration.

e. Sweep Expansion

When the switch on the (X) AMPLITUDE is not actuated, sweep expansion up to a ratio of 4:1 (uncalibrated) may be obtained by this control. Under this condition, use of the X POSITION control enables any portion of the expanded sweep to be displayed on the screen.

The uncalibrated sweep writing rate is contiuously

TABLE 2-3
INITIAL CONTROL SETTINGS FOR DRIVEN SWEEP OPERATION

CONTROL	INITIAL SETTING
X VOLTS FULL SCALE	DRIVen SWEEP
(X) AMPLITUDE	fully CCW
Y VOLTS FULL SCALE	set as determined by amplitude of signal source or at 0.1
(Y) AMPLITUDE	fully CCW
SYNC AMPLITUDE	0
SYNC SELECTOR	INT
INTENSITY	approximately 1/3 CW
FOCUS, X POSITION, & Y POSITION	center of range

PROCEDURE

a. Apply the desired signal to Y INPUT (minimum of 0.4 inch)

b. Adjust SYNC AMPLITUDE to + or — (to initiate the sweep) and rotate X POSITION to center the pattern horizontally

c. Adjust (Y) AMPLITUDE in conjunction with Y VOLTS FULL SCALE to obtain a vertical deflection of about two inches

d. Gradually adjust (X) AMPLITUDE to expand the trace. If display tends to move off screen, either to the left or right, adjust the X DC BAL to position the pattern back on screen

e. Rotate the SWEEP RANGE and VERNIER controls to obtain the desired number of cycles on screen. Readjust SYNC AMPLITUDE if necessary

f. Adjust the INTENSITY and FOCUS controls to obtain a sharp trace at a suitable brightness level

g. If there is any multiple triggering of the sweep, the SYNC AMPLITUDE control may be corrected to select the signal level which will best actuate the gate circuit. Thus, undesirable signals of lesser amplitude will not affect the sweep

TABLE 2-4
CALIBRATED SWEEP WRITING RATES

(X) AMPLITUDE is set fully clockwise to CAL SWP (switch is actuated)

SWEEP RANGE set to	VERNIER settings		
	X1 (rotated fully CW)	X2 (set to X2 dot)	X5 (rotated fully CCW)
	Sweep rates in microseconds per inch		
10 μS/IN	10	20	5
50 μS/IN	50	100	250
250 μS/IN	250	500	1250
	Sweep rates in milliseconds per inch		
1 MS/IN	1	2	5
5 MS/IN	5	10	25
25 MS/IN	25	50	125
EXTC (external capacitor)	Sweep rates in seconds per inch for each microfarad of external capacitance*		
	0.125	0.250	0.625

* Sprague's styracon "B" is recommended

variable over a 5:1 range when the VERNIER control is not set for sweep calibration and the fastest writing rate will be approximately 2.5 microseconds inch.

2-7. OPERATING HINTS FOR THE VERTICAL AMPLIFIER

a. Y DC Bal Adjustment

When this control is properly adjusted, there will be no vertical displacement of the trace with changes in the setting of the (Y) AMPLITUDE control. For adjustment procedure, see paragraph 2-5.

b. Single-Ended Y Input

Signals to be observed are connected to the vertical channel through the Y INPUT terminal and ground. The Y VOLTS FULL SCALE permits capacitive or direct coupling of the signal to the compensated attenuator. The terminals for direct connection to the deflection plates are accessible at the rear of the cabinet. (See paragraph 2-9 for details.)

c. Use of Balanced Input (See Figure 2-1)

For balanced input, remove the link from the normally grounded Y INPUT terminal. The Y VOLTS FULL SCALE must be set to the 0.1 DC position. The following explanation of the balanced-input feature may help the operator determine when this type of operation may be useful.

If there is an in-phase signal (common-mode) riding on the balanced-input signal, the permissible input voltage (dc plus peak ac) will be reduced accordingly.

One of the features of the balanced-input circuit is the differential action of the amplifier. This circuit makes it possible to reject to a considerable degree any common-mode signal, while at the same time passing and amplifying the balanced-input signal. Thus, if there is any pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input amplifier circuit.

The waveforms shown in Figure 2-1 illustrate the advantage of the balanced-input connection over the single-ended connection in such cases. A push-pull test signal on which a common "nuisance" signal is superimposed, is applied to the balanced-input connection of the instrument (Figure 2-1a). Then, this same signal, passed through a network to convert it to unbalanced output, is applied to the unbalanced-input connection of the instrument (Figure 2-1b). Note how much greater the amplitude of the common-mode signal appears with the unbalanced-input connection.

d. Optimum Common Mode Rejection Adjustment

To adjust for the best rejection of the unwanted common-mode signal, remove the jumper from the Y INPUT terminal. Apply a one-volt 60-cycle square-wave signal between both the Y INPUT terminals and ground. Set Y VOLTS FULL SCALE to 0.1 DC and (Y) AMPLITUDE control for minimum deflec-

(a) Balanced Signal Applied to Balanced Y Input

(b) Unbalanced Signal Applied to Unbalanced Y Input (Note: Sweep rate has been decreased)

Figure 2-1. Effectiveness of Balanced Input in Eliminating Common-mode Signals

tion. If this does not reduce the amplitude of the trace to zero, set (Y) AMPLITUDE control approximately midway, and vary the Y DC BAL control for minimum deflection. (It will be necessary to adjust the Y POSITION control as the Y DC BAL adjustment is being made to keep the beam centered vertically on the screen.) As now adjusted, it should be possible to go through the common-mode null with either (Y) AMPLITUDE or the Y DC BAL control.

NOTE: OBSERVATION OF SINGLE-ENDED SIGNALS, AFTER HAVING MADE THESE BALANCED-INPUT ADJUSTMENTS, WILL REQUIRE RESETTING OF THE Y DC BAL AND Y POSITION CONTROLS.

e. Y Calibration

Amplitude measurements of the vertical signal may be made by employment of the built-in voltage calibrator. The calibrator signal is available internally, and may be substituted for the vertical signal by depressing the Y CAL push button. To make use of this signal for amplitude calibration proceed as follows:

Step 1. Depress Y CAL button to obtain pattern on screen

Step 2. Adjust (Y) AMPLITUDE control to give full scale deflection (four inches). Note: Do not touch the (Y) AMPLITUDE after it has been set for signal amplitude measurement; if moved, repeat Step 2

Step 3. Depress Y CAL button to release switch, removing the calibrator pattern

The vertical amplifier now functions as a voltmeter having a sensitivity of 0.1 volt, 1.0 volt, 10 volts or 100 volts full scale depending on the setting of the Y VOLTS FULL SCALE switch. Intermediate sensitivities may be obtained by making an alternate use of the (Y) AMPLITUDE control. For example, if in Step 2, (Y) AMPLITUDE is adjusted for half scale deflection (two inches), the basic sensitivity of the instrument will be 0.2 volt, 2.0 volts, 20 volts or 200 volts full scale. This gives an alternative way of using the instrument.

2-8. OPERATING HINTS FOR THE HORIZONTAL AMPLIFIER

a. General

The Type 401 and 401-R both contain identical horizontal and vertical amplifiers. This results in very small relative phase shift between X and Y signals, provided that the (X) and (Y) AMPLITUDE controls are set comparably. See Table 1-1 for additional information. For those applications where it is desirable to apply an external signal through the horizontal amplifier, the amplifier should first be adjusted for dc balance as outlined in the next paragraph.

b. X DC Bal Adjustment

When this control is properly adjusted, there will be no horizontal displacement of the spot with changes in the setting of the (X) AMPLITUDE control. To adjust, proceed as follows:

Step 1. SET X VOLTS FULL SCALE to OFF and (X) AMPLITUDE fully CCW

Step 2. Center the spot with X POSITION control

Step 3. Set (X) AMPLITUDE control fully CW

Step 4. Recenter the spot with X DC BAL control

Step 5. Repeat steps 1 through 4 until no horizontal displacement of the spot is observed while varying the (X) AMPLITUDE control throughout its range

NOTE: If satisfactory balance cannot be achieved, see Trouble Shooting Chart, Table 4-3, Item 2-3.

c. X Input

When using the horizontal amplifier for external signals (X INPUT), set X VOLTS FULL SCALE to AC or DC. When this switch is set either of these positions, the internal sweep is disconnected and the X INPUT terminals are connected to the horizontal amplifier. However, the sweep gate circuit is not disabled unless the SYNC AMPLITUDE is set at "0." Application of single-ended or balanced signals to X INPUT is identical to that described for the vertical amplifier.

d. X Amplifier Gated Beam Operation

If gated beam operation is desired when using both the vertical and horizontal amplifiers, it can be obtained by triggering the sweep (which is placed in the driven mode when the X VOLTS FULL SCALE is set for external signals) with EXT, INT, or LINE signals just as in normal operation. Thus, it is possible while viewing external signals, to superimpose the brightening gate on the trace. The duration of the brightening gate may be adjusted by the SWEEP RANGE and VERNIER controls. If this feature is not desired, set SYNC AMPLITUDE at "0."

e. X Calibration

The procedure for making amplitude measurements of the horizontal signal is identical to that de-

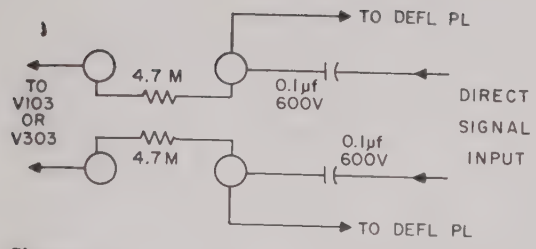


Figure 2-2. Circuit for Deriving Positioning Voltage for Signals Coupled Direct to Deflection Plates

scribed for the vertical amplifier except that the X CAL and (X) AMPLITUDE controls are used.

2-9. DIRECT CONNECTION TO DEFLECTION PLATES

a. General

When applying signals to deflection plates, the highest-frequency signal that can be observed is not limited by the response of the built-in amplifiers but is dependent upon the input capacitance to the deflection plate terminals and/or transit time of the electrons between the deflection plates. Provided the impedence of the signal source is kept low, transit time is the only consideration. It should be remembered, however, that no amplification or attenuation is provided on direct input. See Table 1-1 for deflection sensitivities.

b. Making Proper Connections

CAUTION

Before making connections, shut off power

Direct connection to the deflection plates can be made by removing links on deflection plate terminals at rear panel and by noting the following information:

(1) External deflection plate return resistors must be provided. Single-ended input, 5 megohms (maximum) either plate to ground; balanced input, 10 megohms (maximum) center-tapped to ground.

(2) The average dc potential of approximately 280 volts above ground should be preserved on both pairs of deflection plates for best focus; however the astigmatism adjustment (R412) has sufficient range for most potentials up to +400 volts.

(3) This average dc level should be made adjustable to provide an astigmatism control for optimum focus adjustment.

(4) A loss of positioning will occur.

c. Deriving Positioning Voltages (See Figure 2-2)

A suggested method of resolving the information noted in items (1) through (4) of the preceding paragraph is as follows:

Step 1. Disconnect the appropriate CRT deflection-plate links from their terminals (rear of cabinet)

Step 2. Remove links on Amplifier terminals and bridge each pair of terminals with a series resistor (4.7 megohms) in each leg

Step 3. Connect the signal through blocking capacitors of at least 600 volts dc rating

Step 4. To avoid any possibility of cross-coupling effects, it is suggested that, when connecting a signal direct to deflection plates, the corresponding channel (X VOLTS FULL SCALE and/or Y VOLTS FULL SCALE) controls be switched to OFF

Application of these steps does the following: (1) preserves the deflection-plate voltages, (2) eliminates the need for an external dc biasing voltage and (3), readjustment of astigmatism is not required.

2-10. INTENSITY MODULATION

Positive signals applied to Z INPUT will decrease the beam intensity. To make this connection, shut off the power and apply the signal to the Z INPUT terminal at the rear of the instrument. Note: Z INPUT presents an impedence of 10,000 ohms and 30 μμf to the signal source, capacitively coupled.

2-11. MAKING RISE TIME MEASUREMENTS

Application of signals from an external time calibrator will facilitate pulse rise-time measurements. When making such measurements, the one factor which must be borne in mind for most accurate quantitative results is the pulse response characteristic of the vertical amplifier. This characteristic is related to the observed pulse rise time and the actual pulse rise time in the following manner:

$$t_{ro} = \sqrt{t_{ra}^2 + t_{rp}^2}$$

Where t_{ro} is the observed rise time; t_{ra} is the rise time of the amplifier; t_{rp} is the signal rise time. Once the amplifier rise time is known, the rise time of any pulse may be calculated.

SECTION 3
THEORY OF OPERATION

3-1. GENERAL

In following the theory discussion, it is suggested that the over-all block diagram in Section 1 and the over-all circuit schematics (just inside the back cover of the manual) be referred to in addition to the simplified functional block diagrams in this section.

3-2. VERTICAL DEFLECTION CIRCUIT

a. Input Circuit (See over-all schematic)

The Y VOLTS FULL SCALE switch (S101) selects the desired attenuation of the input signal in decade steps from 0.1 volt to 100 volts full scale for both AC and DC inputs. The OFF position of this switch removes the input signal from the attenuator and grounds the grid (pin 2) of the input dc amplifier (V101-A).

The input decade attenuators are R-C compensated to maintain frequency and phase response and to present an impedance of 2.0 megohms in shunt with 55 μμf (maximum) to the circuit under test, regardless of the attenuation selected.

Provision is made for applying a balanced signal to Y INPUT when the Y VOLTS FULL SCALE switch is set to 0.1 (DC) position. For details on use of this feature, refer to the instructions contained in Operation, paragraph 2-7c.

b. DC Amplifier Operation (See Figure 3-1)

The vertical deflection dc amplifiers comprise V101 through V103, inclusive. The dc balanced circuit arrangement provides good deflection amplifier stability. The input dc amplifier (V101) (which on balanced inputs acts effectively as a differential amplifier) precedes the continuously variable (Y) AMPLITUDE control (R114). R115, in series with this control, prevents the operator from cutting the gain all the way to zero. Thus, any signal greater than full screen may be observed in its entirety only after the attenuator control (Y VOLTS FULL SCALE) is set at a higher voltage position or if the amplitude of the applied signal is reduced.

The normally grounded grid (pin 7) of V101-B is brought out to the front-panel binding post (J102) so that balanced input operation may be obtained

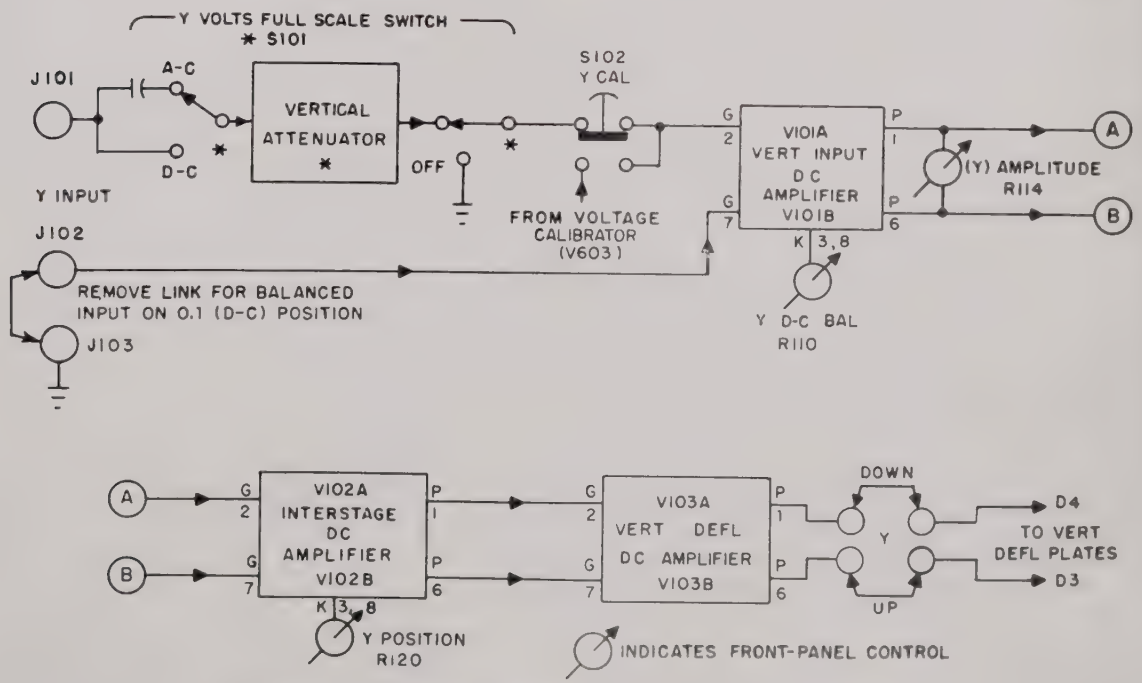


Figure 3-1. Vertical Amplifier Functional Block Diagram

simply by removing the ground link between J102 and J103 (front panel terminals). The resistors (R107 and R108) in series with the grids of V101 serve to protect the input circuit from damage due to excessive input voltage.

A variable capacitor (C119) is provided, which is adjusted to minimize capacitively coupled heater-voltage harmonics. The HUM BAL (R603) service adjustment is set to minimize the fundamental power-line hum component.

The Y DC BAL control (R110) equalizes the voltages at the ends of the (Y) AMPLITUDE control (R114). When this control is properly set, there will be no shifting (up and down) of the trace when (Y) AMPLITUDE control is rotated throughout its range and with no signal applied to the amplifier. This control can also be used in conjunction with Y POSITION control to obtain maximum common mode rejection ratio when using balanced input signals. See Operation, paragraph 2-7d.

For amplitude measurements, a reference potential of 0.1 volt peak-to-peak is applied to the vertical input dc amplifier (V101-A) by means of the push-push Y CAL switch (S102). This switch automatically disconnects the Y INPUT signal from the amplifier when the calibrator signal is applied. For details on making accurate amplitude measurements of the input signal, see Operation, paragraph 2-7e.

The printed wiring capacitors (shown without reference symbols on the over-all schematic) are employed to neutralize input capacitance effects of amplifier action.

Provision is made for direct input to the vertical deflection plates. See Operation, paragraph 2-9, for use of this feature.

3-3. SYNC CIRCUIT (See over-all schematic)

The SYNC SELECTOR switch (S201) provides selection of the synchronizing signal; INT (signal obtained from a tap on the plate lead of V103-B in the vertical channel), LINE frequency, or EXTernal (signal obtained from an external source). V201-B functions as a sync phase splitter. The SYNC AMPLITUDE control (R206) enables the operator to select the desired amplitude and polarity of the sync voltage. Following this control is the series triggering diode which is shunted by a resistor (R208) to facilitate recurrent sweep synchronization. This diode serves as a sync lockout stage during the forward sweep time as follows: When the gate generator is initiated (V202-A and V203-A), the plate of V202-A rises essentially to its plate-supply voltage. Since the cathode of V202-B is connected to this point, V202-B becomes automatically nonconductive during the forward sweep time, thereby reducing the passage of unwanted sync signals.

3-4. GATE AND SWEEP CIRCUITS (See Figure 3-2)

a. Driven Sweep

(1) Gate Generator

V202-A and V203-A are connected as a bistable gate generator. The MODE service adjustment (R213) is set such that, initially, V202-A is fully conducting and V203-A is at cutoff. V203-A is initiated by a positive-going signal applied to its grid, resulting in a sudden transition of V203-A from cutoff to full conduction. Conversely, the other half of the gate generator (V202-A) is turned off. The negative gate developed at the plate of V203-A is coupled to a gate cathode-follower stage (V203-B)

(2) Positive Saw Generation

The negative gate output from the cathode of V203-B is coupled to the grid of the saw discharge tube (V204-A), which is normally conducting and maintaining the sweep range capacitor in a discharged state. This gate turns off V204-A and allows the voltage at its plate to rise at a rate determined by the product of R and C as determined by the setting of the SWEEP RANGE and VERNIER controls. The resultant sawtooth voltage across the range capacitor is coupled to the positive saw cathode follower (V204-B). From the junction of V204-B cathode load resistors (R229 and R230), the sawtooth voltage is applied to the SW DC LEVEL adjustment (R222). When this adjustment is properly set, equal sweep-trace expansion from both sides of the center screen will be obtained as the (X) AMPLITUDE control is rotated. The output from the arm of the SW DC LEVEL adjustment is coupled to the input of the horizontal amplifier by means of the X VOLTS FULL SCALE switch (S301).

The voltage at the cathode of V204-B is fed back to the grid of the nonconducting gate tube (V202-A) via an R-C coupling network (R219 and C205). This restores the gate generator to its initial operating condition (when the positive saw reaches a pre-determined level) thus terminating the sweep. The beam will sweep the screen again only upon the application of another positive-going signal to the grid of V203-A.

A high degree of linearity is achieved by causing the dc voltage of the charging source to rise at saw rate through use of a gas tube (E202) coupled to the sweep charging resistors (R232, R233 and R223). This essentially provides a constant-current charging source for the sweep capacitor. Since the charge across any capacitor is directly proportional to the current flowing into it, a constant (unvarying) current results in a uniform increase in charge or a linear sawtooth waveform.

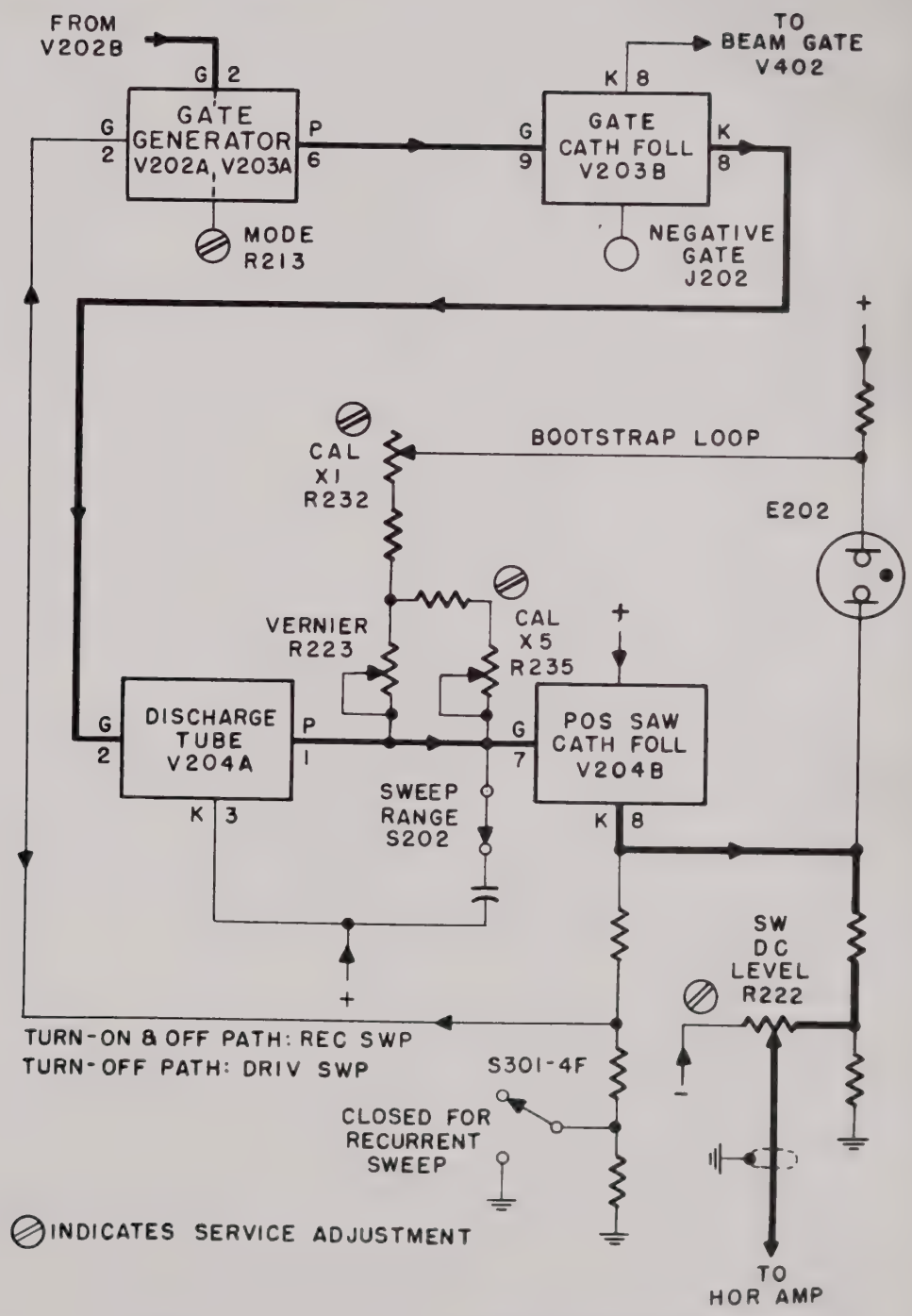


Figure 3-2. Gate and Sweep Circuits, Simplified Schematic

The CAL X1 (R232) and CAL X5 (R235) adjustments are used for setting the VERNIER ratios for calibrated sweep; further details are given in the Service Adjustment Chart, Table 4-2.

b. Recurrent Sweep

When the X VOLTS FULL SCALE switch is set at RECurrent SWEEP, the top of R226 in the saw-divider network is returned to the ground. This action establishes a new dc level of the feedback path to V202-A such that the saw-return trace is able to initiate this stage. Under these conditions, the gate generator (V202-A and V203-A) will essentially be free running. Subsequent development of the positive saw is similar to that described for driven sweep.

RECurrent SWEEP synchronization is acomplished near the end of the forward-sweep trace; for DRIVen SWEEP, it is achieved at the start of the forward sweep. Consequently, a phase change of 180° will be noted when switching from DRIVen to RECurrent SWEEP or vice versa.

3-5. HORIZONTAL AMPLIFIER CIRCUIT (See Figure 3-3)

Since identical vertical and horizontal amplifiers are employed in the Type 401/401-R, the previously discussed theory for the vertical amplifier is equally applicable, except for the X VOLTS FULL SCALE and (X) AMPLITUDE controls. For use and functions of these controls see Section 2, Operation.

By means of the X VOLTS FULL SCALE switch, provision is made for the selection of internal or external signals for horizontal deflection. The internal signal is obtained from the driven or recurrent sweep circuits described earlier. External signals may be applied to the X INPUT terminals.

When the X VOLTS FULL SCALE switch is set for external signals, the sweep circuit is not disabled unless the SYNC AMPLITUDE control is set at "0." Thus, it is possible to trigger the sweep, while viewing external signals, to superimpose the brightening gate on the trace. For use of this feature, see Operation, paragraph 2-8d.

3-6. CATHODE-RAY TUBE AND BEAM GATE CIRCUITS (See over-all schematic)

a. Cathode-ray Tube

A Type 5ADP– cathode-ray tube (V401) is used, operating at a total accelerating potential of approximately 3000 volts.

b. Focus

Focusing of the beam for maximum sharpness of trace is accomplished by adjusting the FOCUS

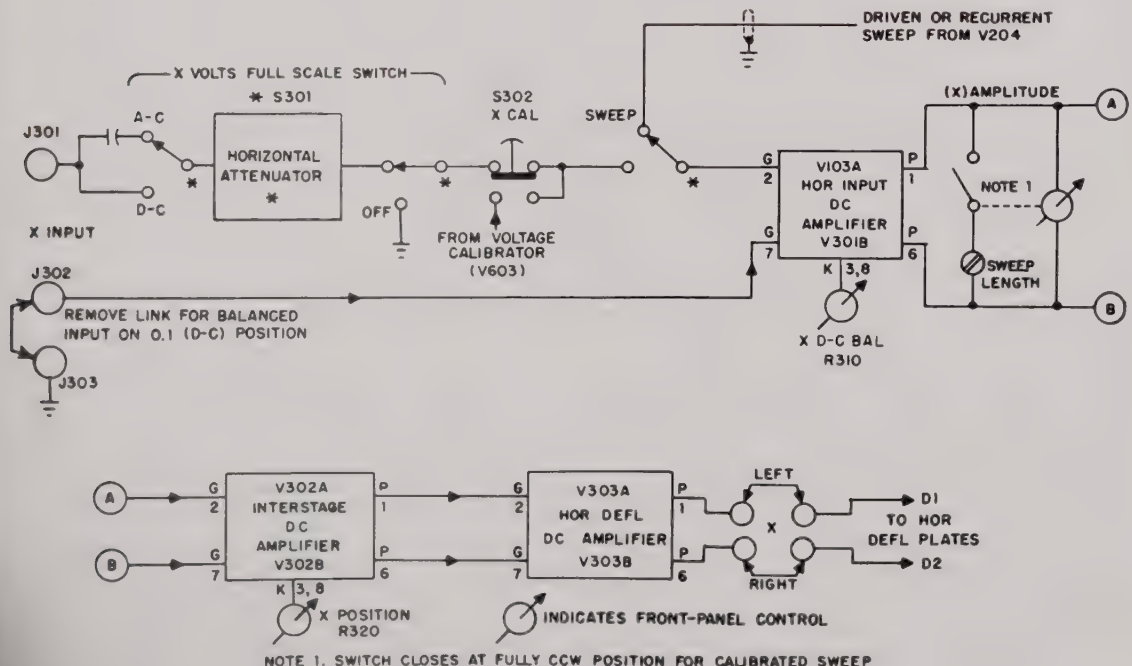


Figure 3-3. Horizontal Amplifier Functional Block Diagram

control (R411). The setting of this control establishes the relative potential difference between the focus anode and cathode. The vertical deflection plates (D3 and D4) and the horizontal deflection plates (D1 and D2) operate at an average dc potential of approximately 280 volts above ground. To avoid beam distortion, the second anode must operate at approximately the same dc potential. The second anode voltage is derived from the arm of the ASTIGmatism service adjustment (R412).

c. Intensity Modulation

For intensity modulation of the beam, positive (blanking) negative (brightening) signals may be applied to the Z INPUT terminal through a coupling capacitor (C402) to the cathode of the cathode-ray tube. See Table 1-1 for additional information.

d. Beam Gate and Intensity Circuits (See over-all schematic)

(1) General Description

The primary functions of the gate generator (V402) are (1) to provide return trace blanking for recurrent sweep operation and (2) when driven sweep operation is desired, to automatically turn on the cathode-ray tube beam for the duration of the forward sweep interval and then turn it off automatically at the end of this interval. This latter feature prevents film fogging and/or screen burning prior to the initiation of driven sweep.

A secondary function of the gate generator is to facilitate transfer of the source of the brightening gate from a low dc level (approximately 150 volts) to the high dc level of the cathode-ray tube grid (negative high voltage).

The primary and secondary functions are solved by the incorporation of a conventional bistable multivibrator (V402—beam gate generator). The mean dc level of this stage is equal to the average level of the cathode-ray tube accelerating potential. Thus, only short pulses are needed to trigger V402 on or off, enabling the use of a much smaller coupling capacitor.

(2) Detailed Description

Under stable conditions, the constants of the beam gate circuit are such that V402-B is at cut-off and V402-A fully conducting. When the sweep starts, the negative leading edge of the gate coupled from the cathode of V203-B is applied to the grid (pin 2) of V402-A, turning off this stage and turning on V402-B. Thus, the grid of the cathode-ray tube is held above cutoff for the duration of the forward sweep time. V402 is restored to its original condition by the positive-going trailing edge of the sweep gate.

(3) Intensity

The INTENSITY control (R413) is in series with the beam gate generator (V402). The output of V402 is connected to the grid of the cathode-ray tube (V401). Adjustment of the INTENSITY control varies the negative grid potential of V401 with respect to its cathode, which is held at a fixed positive potential relative to the −1300-volt supply by neon lamps E401 and E402.

3-7. REGULATED RF SUPPLY (See over-all schematic)

a. General Description

Operating potentials for the proper intensity and focusing of the cathode-ray tube beam, are derived from the regulated rf power supply. This circuit consists of an rf power oscillator (V501), an rf type transformer having a high turns ratio and a ferrite core (T501), a two stage direct-coupled control amplifier (V504-A, B), a −1300-volt diode rectifier (V502), and a +1800-volt diode rectifier (V503). Regulation is accomplished by sampling a portion of the rectified output, and feeding a correcting signal back through V504 to the screen grid of V501.

b. Detailed Description

The rf power oscillator (V501), operating in the vicinity of 150-200 kc, develops an ac potential across the primary of T401. The amplitude of this voltage is proportional to the screen voltage applied to V501. Hence, a change in the rectified output can be corrected by an appropriate increase or decrease in V501 screen potential. For example, a decrease in the rectified output would result in error voltage fed back to a two stage direct-coupled control amplifier (V504-A and V504-B). These stages supply the correction signal which is coupled to the screen of V501. The screen voltage is increased, which increases the ac output voltage across T401, thus, compensating for the decrease in output voltage mentioned earlier.

The advantages of an rf supply system of generating cathode-ray tube accelerating potentials, compared to that of a conventional "brute force" low-frequency system are:

(1) Relative ease of incorporating control amplifiers to maintain constant, effectively low output impedance.

(2) Elimination of high-voltage, high-capacitance filters, which are dangerous and bulky.

(3) Sharp reduction in shock hazard due to the smaller capacitors used in the filter system.

section 3
theory of operation

3-8. LOW-VOLTAGE POWER SUPPLY
(See over-all schematic)

A self-regulating power transformer (T601) employing a magnetic shunt and a resonant secondary winding is used to minimize the effect of line-voltage variation. Once resonance is attained, it is used in conjunction with the magnetic shunt as the basis of maintaining the output voltage of the transformer constant.

V601 is connected in a conventional full-wave rectifier circuit. The rectified output is filtered by a capacitor-input type filter (C601-C, L601 and C601-B).

3-9. VOLTAGE CALIBRATOR
(See over-all schematic)

The power-line frequency voltage from T601 is applied to the voltage calibrator (V603) through limiting resistor R615. With the plate of V603-A (pin 7) tied to ground, any negative voltage impressed on this section will cause conduction, thus clamping the negative half cycle at approximately ground potential. On the positive half cycle, the voltage conduction occurs in the other half section (V603-B) when the peak applied potential exceeds +150 volts, thus clipping the sine wave at that point. The resulting clipped sine wave voltage (150 volts peak-to-peak) is applied to two parallel voltage dividers; R611 and R612 (Y CAL ADJ) and R614 (X CAL ADJ).

The attenuated output (0.1 volt peak-to-peak) is coupled from the respective voltage divider to the corresponding vertical or horizontal amplifier when the appropriate calibrator button is pushed in. The Y CAL ADJ (R612) and X CAL ADJ (R614) service adjustments provide a means of setting the output of the calibrator to exactly 0.1 volt peak-to-peak.

SECTION 4
MAINTENANCE

WARNING

POTENTIALS AS HIGH AS 3000 VOLTS EXIST IN THIS INSTRUMENT. OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE CABINET REMOVED.

(1) Never work alone.
(2) Make sure the chassis is properly grounded.
(3) Disconnect power before changing any tubes.
(4) Before touching any component, short the terminals to remove any possible charge that may remain after removing the power.

4-1. GAINING ACCESS TO THE CHASSIS

The unit is enclosed in a cabinet which is composed of six removable panels (top, bottom, left, and right sides; upper and lower panels at the rear). To gain access to the chassis, remove the four screws securing each side panel. This will expose most of the tubes and service adjustments for normal maintenance.

After the side panels are removed, the top and bottom panels may be taken off if desired. To take off the bottom panel, remove the two flat head screws located on the fold-over on each side. The top panel is similarly removed except that two additional screws, located at either end of the handle, must be removed. Note: the top panel will not normally require removal. To take off the upper or lower rear panel, remove the four screws securing them to the frame.

4-2. SERVICE ADJUSTMENTS

Do not touch any service adjustments unless test clearly indicates the need to do so. Such adjustments should not be attempted without a complete understanding of the proper procedure. Consult Tables 4-1 and 4-2 for special instructions.

4-3. GENERAL TROUBLE SHOOTING

The first step in correcting any trouble or failure that may occur is to isolate the section of the circuit causing the trouble. Such isolation can be accomplished by considering the circuit as composed of the basic sections shown in the over-all block diagram, Figure 1-2. As an aid to servicing, Trouble Shooting Chart, Table 4-3, has been provided.

The next step after isolating the trouble to a particular section is to determine the specific tube circuit involved. A replacement tube should be tried before attempting any other test. Tubes may be located by reference to Figures 4-1 through 4-2.

NOTE

Indiscriminate tube changing must be avoided. If after tube replacement, the trouble persists, replace the original tube in its socket. Replacement of certain tubes will require resetting of one or more service adjustments. Consult Table 4-4 for special instruction.

If trouble persists, voltage and resistance measurements should be made. See Tables 4-5 and 4-6.

4-4. REPLACEMENT OF CATHODE-RAY TUBE

CAUTION

The cathode-ray tube should be handled with great care to prevent breakage and/or serious personal injury from flying glass. Do not employ force at any time. As an added precaution, it is advisable to wear safety goggles and gloves.

The following step-by-step procedure is suggested for replacing the cathode-ray tube:

1) Turn off power; remove rear plate secured by four screws and the side panels.
2) Remove bezel, held by four screws at front panel.
3) Remove the cathode-ray tube socket and the intensifier button.
4) Loosen the cathode-ray tube clamp via screw through the access hole (located on the same side as the intensifier button).
5) Remove tube through front panel opening.
6) Remove the rubber clamp from the old tube and install it on the new tube.
7) Install new tube through front panel opening, and replace the bezel.
8) Replace the tube socket and the intensifier button.
9) Apply power and check the sweep; if not horizontal, rotate the tube by the insulated handle as required.

10) Tighten the cathode-ray tube clamp securely to prevent rotation in handling. It is not possible to damage the tube in tightening due to the protection provided by the rubber clamp.

4-5. ILLUMINATED SCALE LAMP AND PILOT LAMP REPLACEMENT

a. Defective scale lamps are removed as follows:

1) Turn off power and remove the side panels.

2) Remove the appropriate lamp assembly located on the rear side of the front panel by depressing the spring clip. The defective bulb may then be removed and replaced.

b. Defective pilot lamp is removed as follows:

1) Turn off power and remove bottom panel.

2) With the unit upside down, replace the defective bulb.

Note: Bulb removal is made easier by taking off the sync shield which is secured by the hexagon nut holding the SW DC LEVEL potentiometer.

4-6. WARRANTY AND SERVICE NOTICE

All instruments produced by the Technical Products Division of Allen B. Du Mont Laboratories, Inc., are sold under the Du Mont Warranty. For the provisions of this warranty and of the Technical Products Service policies, see the Warranty and Service Notice on the inside back cover.

TABLE 4-1
TEST EQUIPMENT REQUIRED FOR SERVICE ADJUSTMENTS

REF. No.	DESCRIPTION	RANGE OR CHARACTERISTICS
(1)	Volt-ohmmeter	20K ohms/volt Test Meter or Electronic Voltmeter
(2)	Square-wave Generator	1 kc to 10 kc
(3)	Voltage Calibrator	0.1 to 100 volts peak-to-peak; ±1%
(4)	Time Calibrator	Pulse repetition rate: 100 cps, 1 kc, 10 kc, 100 kc, and 1 mc; accuracy required ±1% or better; 2 volts peak

PRECAUTION

DO NOT SET ANY SERVICE ADJUSTMENT WITHOUT FOLLOWING SPECIFIC INSTRUCTIONS AND SEQUENCE GIVEN IN TABLE 4-2. SOME ADJUSTMENTS ARE INTERDEPENDENT.

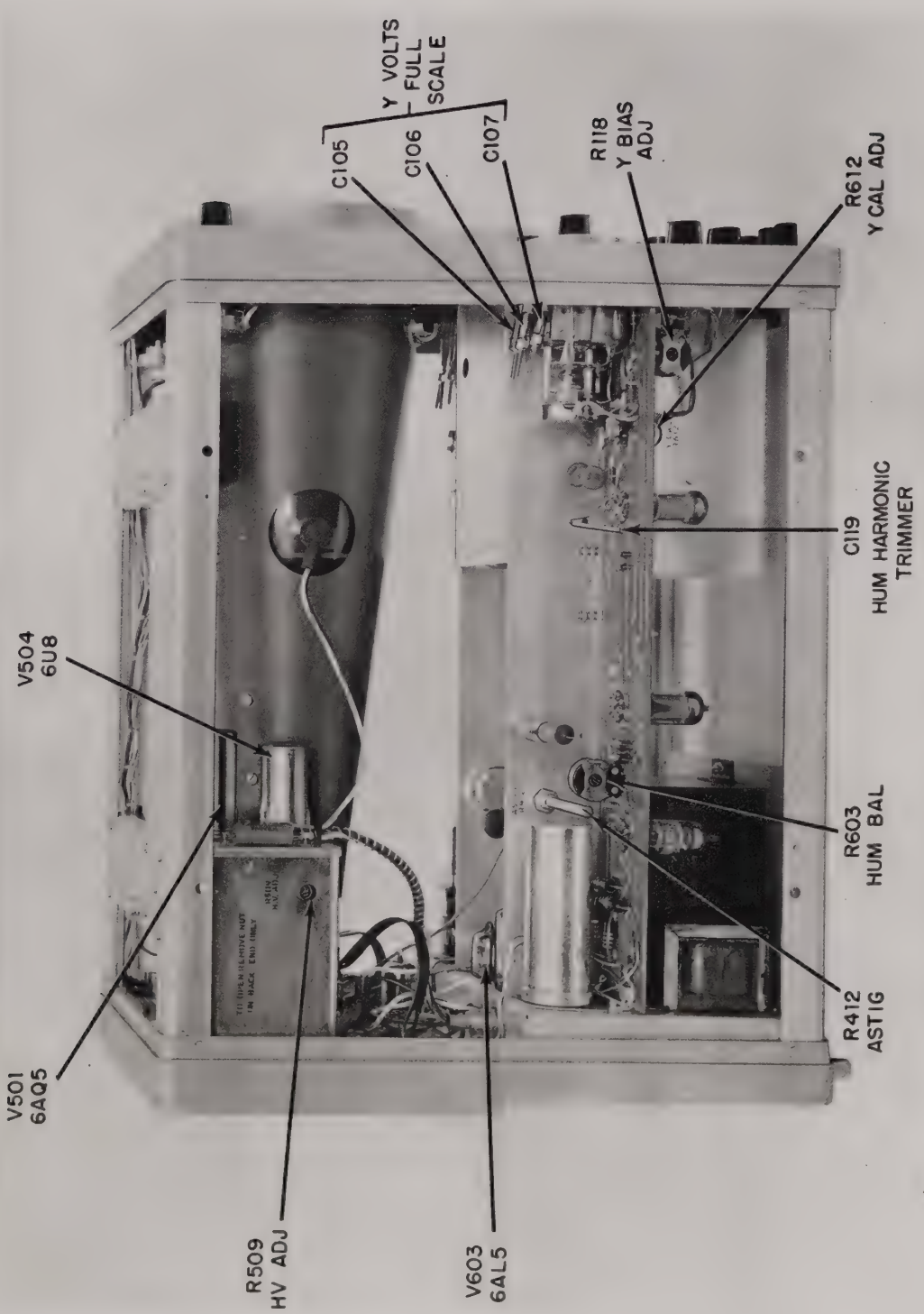


Figure 4-1. Service Adjustments and Tube Locations, Left Side View

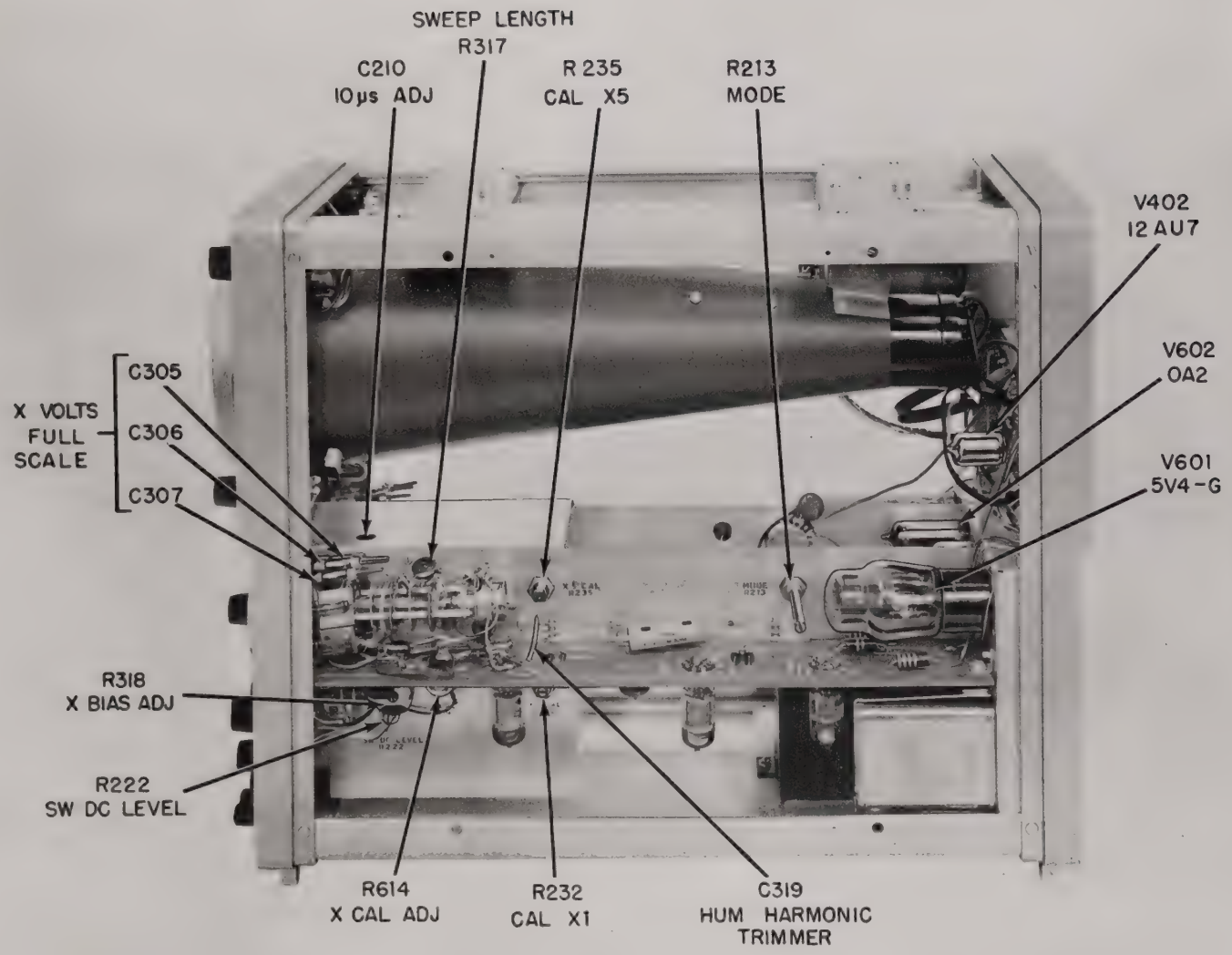


Figure 4-2. Service Adjustments and Tube Locations, Right Side View

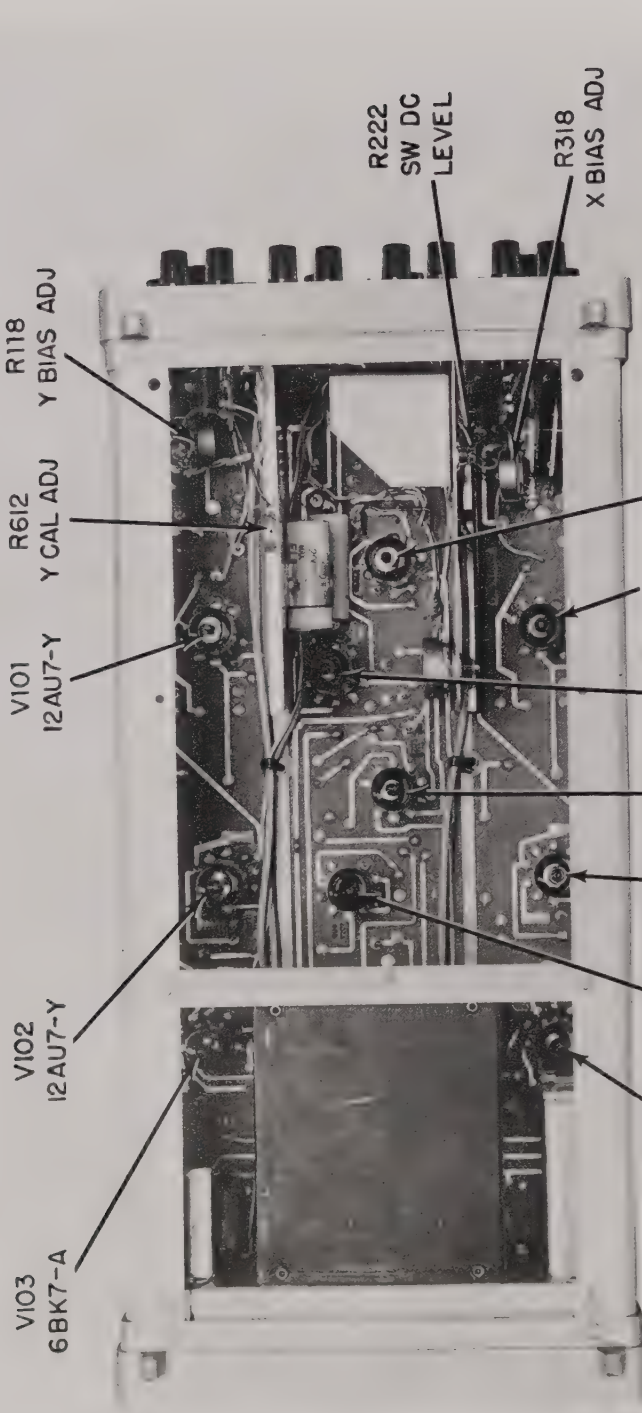


Figure 4-3. Service Adjustments and Tube Locations, Bottom View

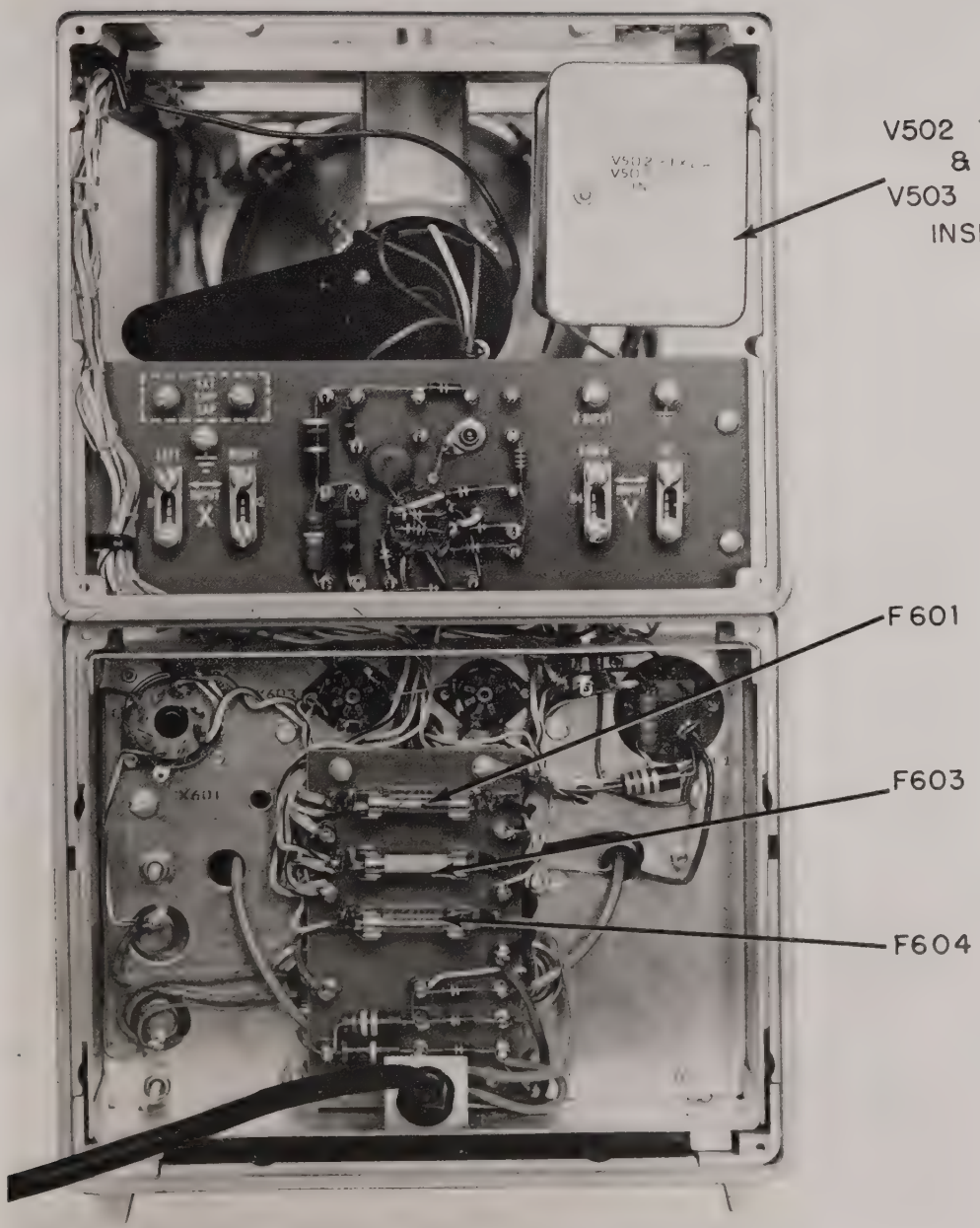


Figure 4-4. Tube and Fuse Locations, Rear View

TABLE 4-2
SERVICE ADJUSTMENT CHART

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
		POWER SUPPLY AND CRT
HV ADJ (R509) Fig. 4-1	(1)	Set INTENSITY fully CCW; use an insulated test probe and adjust the high-voltage negative supply to —1300 volts. This supply can also be set to a lesser voltage (as low as —1200 volts) to permit calibration of X amplifier if the amplifier is slightly low on gain NOTE: the — 1300-volt supply can be measured from the CCW end (white wire) of the INTENSITY control (—) and chassis (+)
ASTIG (R412) Fig. 4-1	—	To adjust, set appropriate front-panel controls to obtain spot on screen. Adjust R412 simultaneously with the FOCUS control for minimum spot size at normal INTENSITY setting. When R412 is properly adjusted, the de-focused spot will be round as the FOCUS control is rotated both CW and CCW from sharpest FOCUS setting
HUM BAL (R603) and Hum Harmonic Trimmers (C119 and C319) Figs. 4-1 & 4-2	—	Check by setting both (X) and (Y) AMPLITUDE fully CW and X and Y VOLTS FULL SCALE fully CCW. Shield both X and Y INPUT terminals. The power-line frequency ripple should not exceed 0.02 inch. If it does, adjust R603 (to neutralize 60-cycle fundamental hum), C119 (to neutralize harmonics of 60 cycles at Y INPUT), and C319 (to neutralize harmonics at 60 cycles at X INPUT)
		SWEEP CIRCUITS
MODE (R213) Fig. 4-2	—	Improper adjustment of R213 will show up either as operation of the sweep in the DRIVen mode with the SYNC AMPLITUDE control at "0" or failure of the sweep to operate in the RECurrent mode. To adjust, set X VOLTS FULL SCALE to DRIVen SWEEP and SYNC AMPLITUDE to "0." Adjust R213 just below the threshold of recurrent sweep. Set SYNC SELECTOR to LINE. Check that a slight rotation of the SYNC AMPLITUDE control in either direction causes the sweep to operate
SW DC LEVEL (R222) Fig. 4-2	—	1) Check that the X DC BAL is properly set; see Operation, paragraph 2-8b 2) Center the spot with the X POSITION control 3) Set X VOLTS FULL SCALE to RECurrent SWEEP, SYNC AMPLITUDE to "0," and adjust sweep controls for a trace 4) Adjust R222 to make the sweep expand equally on either side of center as the (X) AMPLITUDE is varied
		Sweep Calibration Procedure
SWEEP LENGTH (R317) Fig. 4-2	—	1) Set SWEEP RANGE to 1 MS/IN, VERNIER fully CW to X1, X VOLTS FULL SCALE to RECurrent SWEEP, and (X) AMPLITUDE fully CW to CAL SWP 2) Adjust R317 for a sweep length between the limits of 4 and 4.4 inches Note: Adjust for slightly more than four inches to give adequate sweep on all ranges and to allow for some sweep shortening due to sync
CAL X1 (R232) Fig. 4-2	(4)	3) Set X VOLTS FULL SCALE to DRIVen SWEEP and SYNC SELECTOR to EXT 4) Apply 1 kc (1 millisecond) markers to Y INPUT and to EXTERNAL SYNC 5) Adjust R232 for a sweep writing rate of 1 milliseconds/inch (one marker per inch)

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
SWEEP CIRCUITS		
CAL X5 (R235) Fig. 4-2	(4)	6) Rotate VERNIER fully CCW to X5 7) Adjust R235 for a sweep writing rate of 5 milliseconds/inch (one marker per minor division; i.e. 0.2 inch) 8) Adjust VERNIER for a sweep writing rate of 2 milliseconds/inch (one marker every 2-1/2 minor divisions). If necessary, loosen the VERNIER knob and reset it to the white dot adjacent to X2 on the panel
10 μs ADJ (C210) Fig. 4-2	(4)	9) Set SWEEP RANGE to 10 μS/IN and rotate VERNIER fully CW to X1 10) Apply 100 kc (10 microseconds) markers to Y INPUT and adjust C210 for a sweep writing rate of 10 microseconds/inch (one marker per inch)
VERTICAL DEFLECTION AMPLIFIER		
Y VOLTS FULL SCALE Compensation Capacitors Fig. 4-1	(2)	Apply a 10 kc square wave to Y INPUT and adjust capacitors listed to obtain a flat-top square wave Y VOLTS FULL SCALE set to — Adjust 0.1 — ..... 1.0 — C105 10 — C106 100 — C107
Y BIAS ADJUST (R118) Fig. 4-1	(1) & (2)	1. Check that the Y VOLTS FULL SCALE Compensation Capacitors are properly adjusted 2. Set Y VOLTS FULL SCALE to 10 AC and (Y) AMPLITUDE to center of range 3. Apply a 10 kc square wave signal of 5 volts peak-to-peak to Y INPUT 4. Adjust (Y) AMPLITUDE for a vertical deflection of 1.2 inches (6 minor scale divisions) 5. Set Y VOLTS FULL SCALE to 1.0 AC (this produces a vertical deflection of 3 times full scale) 6. Position both the top and bottom of the square wave up and down the full height of the screen and note if there is any change in the overpeaking 7. Adjust R118 for minimum change in overpeaking 8. When R118 is properly adjusted, the voltage from the plate of V102 (pin 1 or 6) to ground should measure approximately 115 volts; at the vertical deflection plates (rear panel board), approximately 280 volts 9. Recheck Y VOLTS FULL SCALE Compensation Capacitors
Y CAL ADJ (R612) Fig. 4-1	(3)	Set Y VOLTS FULL SCALE to 0.1 DC and apply a 0.1 volt ±1% signal from an external voltage calibrator to Y INPUT. Advance (Y) AMPLITUDE for exactly four inches of vertical deflection (full scale). Next, push in the Y CAL button and adjust R612 for the same four-inch vertical deflection

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
HORIZONTAL DEFLECTION AMPLIFIER		
X VOLTS FULL SCALE Compensation Capacitors Fig. 4-2	(2)	Apply a 10 kc square wave to X INPUT. Proper adjustment of the capacitors listed is obtained when the dots at each end of the horizontal trace are of maximum relative intensity and in sharpest focus Y VOLTS FULL SCALE set to — Adjust 0.1 — 1.0 — C305 10 — C306 100 — C307
X BIAS ADJUST (R318) Fig. 4-2	(1) & (2)	1. Check that the X VOLTS FULL SCALE Compensation Capacitators are properly adjusted 2. Set X VOLTS FULL SCALE to 10 AC and (X) AMPLITUDE to center of range 3. Couple a sawtooth waveform from an external source (another oscillograph) to Y INPUT 4. Connect a lead from the output of the square wave generator to EXT SYNC on the Type 401 and set SYNC SELECTOR to EXT 5. Apply a 10 kc square wave signal of 5 volts peak-to-peak to X INPUT 6. Adjust (X) AMPLITUDE for a horizontal deflection of 1.2 inches (6 minor scale divisions) 7. Set X VOLTS FULL SCALE to 0.1 AC (this produces a horizontal deflection of 3 times full scale) 8. Position both the top and bottom of the square wave left and right the full width of the screen and note if there is any change in the over-peaking 9. Adjust R318 for minimum change in overpeaking 10. When R318 is properly adjusted, the voltage from the plate of V302 (pin 1 or 6) to ground should measure approximately 115 volts; at the horizontal deflection plates (rear panel board), approximately 280 volts 11. Recheck X VOLTS FULL SCALE Compensation Capacitators
X CAL ADJ (R614) Fig. 4-3	(3)	Set X VOLTS FULL SCALE to 0.1 DC and apply to 0.1 volt, ±1%, signal from an external voltage calibrator to X INPUT. Advance (X) AMPLITUDE for exactly four inches of horizontal deflection (full scale). Next, push in the X CAL button and adjust R614 for the same four-inch horizontal deflection.

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-3
TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
POWER SUPPLY AND CRT CIRCUITRY		
1-1. Pilot indicator fails to light	1-1a. Line cord not plugged into a live outlet	1-1a. Trace line failure
	1-1b. Blown primary fuse (F604)	1-1b. Check and replace
	1-1c. POWER/SCALE control defective (S601 & R617)	1-1c. Replace POWER/SCALE control
	1-1d. Pilot indicator lamp open (I601)	1-1d. Replace I601
1-2. Line fuse blows instantly when POWER/SCALE switch is turned on	1-2. Defective line cord or primary circuitry	1-2. Place an ohmmeter across prongs of line cord and check continuity in the ON position; resistance should measure approximately 5 ohms
1-3. B+ fuse (F601) blows after approximately one minute when POWER/SCALE switch is turned ON	1-3a. Short on +390- and/or +410-volt bus	1-3a. WARNING PERSONAL CONTACT WITH THE +390-VOLT SUPPLY MAY PROVE FATAL Check resistance of V601 per Table 4-6; also refer to over-all schematic for circuit tracing the short
	1-3b. Shorted filter capacitor(s)	1-3b. Check that C601-A, C601-B, and C601-C are not shorted to ground
1-4. No spot on cathode-ray tube screen	1-4a. Spot might be depositioned due to a defective amplifier stage	1-4a. See 2-1b and/or 4-1b
	1-4b. Spot might be depositioned due to a disconnection between the amplifier and the deflection plates	1-4b. Check that the X and Y deflection plate links are properly connected on terminal board located at rear of cabinet
	1-4c. Defective high-voltage supply	1-4c. Check positive high-voltage rectifier (V503) and negative high-voltage rectifier (V502). Measure voltage and resistance per Tables 4-5 and 4-6
	1-4d. Defective low-voltage supply	1-4d. The low voltages are required for application to the rf power oscillator (V501) and the dc regulator amplifier (V504). See 1-3a and 1-3b for checking procedure
	1-4e. Defective cathode-ray tube	1-4e. Check to see if tube is lit or feel for warmth. CAUTION: HIGH VOLTAGE
	1-4f. CRT not properly seated in its socket	1-4f. Check to see that CRT is properly seated in socket
1-5. Output voltages "very low"	1-5. C602 may be defective	1-5. C602 has been selected to resonate with T601. If replacement is necessary, replace it with one having the same color dot stamped on the end of laminations (SOLA)
1-6. Output voltage varies. Line voltage within tolerance	1-6. Line frequency varies	1-6. T601 is intended for use with 60-cycle power line mains (or 50-cycle if so marked on front panel). Changes in the frequency of the supply voltage will be directly reflected in the output voltage. A change of about 1.8% in output voltage will occur for every 1% change in input frequency, and in the same direction as the frequency change

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
POWER SUPPLY AND CRT CIRCUITRY		
1-7. Excessive spot size variation as it is positioned over the screen (non-uniform focus)	1-7. ASTIG adjustment (R412) improperly set	1-7. See Service Adjustment Chart, Table 4-2
1-8. Uniformity of trace brightness varies with INTENSITY settings	1-8a. Stray pick-up at Z INPUT terminal (idle connector or cable is coupled to terminals)	1-8a. Short out Z INPUT
	1-8b. Also, rf on trace will give this effect (intensity markers). rf ripple in supply	1-8b. Check filter capacitors (C501 and C505) by shunting another capacitor across the suspected one before replacing
1-9. RF pickup	1-9. Loose rf shield or cover on the rf supply	1-9. Check and tighten if necessary
1-10. Bright spot at left side of screen	1-10. Defective beam gate circuit (V402)	1-10. Replace V402. See Tables 4-5 and 4-6 for checking voltage and resistance measurements
1-11. Calibrator pattern rounded on top or bottom looks like a sine wave	1-11. V603 defective	1-11. Replace V603
1-12. No calibration pattern when Y CAL button is pushed in and (Y) AMPLITUDE set fully CW	1-12a. Y CAL ADJ (R612) set fully CW; hence no signal	1-12a. See Service Adjustment Chart, Table 4-2
	1-12b. Defective voltage calibrator (V603) or divider network (R609, R611, and R612)	1-12b. Check and replace defective components(s)
	1-12c. Defective vertical amplifier	1-12c. See 4-1b
	1-12d. Y CAL switch defective (S102)	1-12d. Repair or replace
1-13. No calibration pattern when X CAL button is pushed in and (X) AMPLITUDE is set fully CW	1-13a. X CAL ADJ (R614) set fully CW; hence no signal	1-13a. See Service Adjustment Chart, Table 4-2
	1-13b. Defective voltage calibrator (V603) or divider network (R610, R613, and R614)	1-13b. Check and replace defective component(s)
	1-13c. Defective horizontal amplifier	1-13c. See 2-1b
	1-13d. X CAL switch defective (S302)	1-13d. Repair or replace

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
HORIZONTAL DEFLECTION AMPLIFIER		
2-1. No calibration pattern when X CAL switch is pushed in	2-1a. Defective calibrator circuitry	2-1a. See 1-13
	2-1b. Defective horizontal amplifier	2-1b. (1) To check, short together the plates of V303. If trace returns to center, one or more horizontal amplifier stages are defective (2) Try the one-at-a-time method of replacing the following tubes: Horizontal deflection dc amplifier, V303 Interstage dc amplifier, V302 Horizontal input dc amplifier, V301 NOTE: The original tube should be restored to its socket if not found to be defective (3) A check of voltage and resistance may reveal other defective component(s).
2-2. Cannot position trace on screen when X VOLTS FULL SCALE is set for external signals	2-2. X DC BAL control is set either fully CW or CCW and (X) AMPLITUDE is set fully CW	2-2. Set (X) AMPLITUDE fully CCW. Trace may now be positioned on screen regardless of X DC BAL control setting
2-3. X VOLTS FULL SCALE is OFF. CRT spot shifts (left or right) with changes in setting of (X) AMPLITUDE control	2-3. When using horizontal amplifier for application of external signals, X DC BAL control must be adjusted first	2-3. The X DC BAL adjustment procedure is given in Section 2, Operation. If satisfactory balance cannot be achieved, replace V301. This tube is preselected and may prove critical in replacement. The Du Mont Instrument Service Department can supply this selected tube
2-4. X VOLTS FULL SCALE set for external signals. No trace when set for AC; OK for DC	2-4a. Input coupling capacitor open (C301)	2-4a. Replace C301
	2-4b. Defective X VOLTS FULL SCALE switch	2-4b. Check switch section S301-2R
2-5. A 10 kc square wave is distorted at any one range of the X VOLTS FULL SCALE switch (AC or DC)	2-5. Improper adjustment in the associated X VOLTS FULL SCALE compensation capacitor and/or X BIAS ADJUST (R318)	2-5. See Service Adjustment Chart, Table 4-2
SWEEP AND SYNC CIRCUIT		
3-1. No sweep, X VOLTS FULL SCALE at RECurrent SWEEP	3-1. Defective horizontal amplifier	3-1. To check, push in the X CAL switch and rotate (X) AMPLITUDE CW. A horizontal trace with bright spots at the ends indicates that the horizontal amplifier is OK. If calibration pattern does not appear, see 2-1a and 2-1b

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
SWEEP AND SYNC CIRCUITRY		
3-2. No sweep X VOLTS FULL SCALE at RECurrent SWEEP. Horizontal deflection circuit checks OK	3-2a. MODE adjustment (R213) improperly set	3-2a. See Service Adjustment Chart, Table 4-2
	3-2b. Defective gate circuitry (V202-A & V203)	3-2b. (1) Connect the NEGATIVE GATE terminal to Y INPUT and check for a vertical deflection (2) If vertical trace is present, trouble lies in the sweep circuit; see 3-2c (3) If vertical trace is missing, replace V202 and V203 (4) A check of voltage and resistance may reveal other defective component(s)
	3-2c. Defective sweep circuitry (V204)	3-2c. Replace V204
	3-2d. Recurrent sweep gate turn-on path defective	3-2d. Check continuity of path from junction of R227 and R228 to the grid (pin 2) of V202-A
	3-2e. No continuity from sweep circuit to horizontal amplifier	3-2e. Check continuity from junction of R229 and R230 to grid (pin 2) of V301-A. This checks the continuity of the shielded cable between the sweep and horizontal circuits; also checks X VOLTS FULL SCALE switch sections S301-3R and S301-3F
3-3. No effect on sweep mode when X VOLTS FULL SCALE is switched from DRIVen to RECurrent SWEEP	3-3. Junction of R226 and R227 not tied to ground in RECurrent SWEEP position	3-3. Check X VOLTS FULL SCALE switch; section S301-4F, which shunts R226 to ground in RECurrent position
3-4. No sweep in any one range of the SWEEP RANGE switch. (X VOLTS FULL SCALE set to RECurrent SWEEP)	3-4a. Short in the associated SWEEP RANGE capacitor Note: (open capacitor will cause a low sweep range to shift to highest range i.e. (approximately 10 μS/IN)	3-4a. SWEEP RANGE set to — Defective Capacitor 10 μS/IN — C209 and/or C210 50 μS/IN — C211 250 μS/IN — C212 1 MS/IN — C213 5 MS/IN — C214 25 MS/IN — C215
	3-4b. Defective SWEEP RANGE switch (S202)	3-4b. Repair or replace
3-5. VERNIER has little or no effect on sweep writing rates	3-5. Shorted or open wiper on VERNIER potentiometer (R223)	3-5. Check R223 and replace
3-6. Sweep fails to expand equally in both directions as the (X) AMPLITUDE control is advanced	3-6. SW DC LEVEL (R222) improperly adjusted	3-6. Check dc balance adjustment of X amplifier and see Service Adjustment Chart, Table 4-2

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
SWEEP AND SYNC CIRCUITRY		
3-7. Inaccurate sweep rates observed on any one range (all other ranges OK)	3-7a. Defective SWEEP RANGE capacitor in the range under observation	3-7a. See 3-4a for the capacitor corresponding to the SWEEP RANGE selector switch setting (component tolerance required is ±1%)
	3-7b. C210 improperly adjusted	3-7b. See Service Adjustment Chart, Table 4-2
3-8. All calibrated sweep writing rates are either too fast or too slow (VERNIER ratios OK at X1, X2, and X5)	3-8a. Variation of horizontal amplifier gain due to improper adjustment of SWEEP LENGTH (R317)	3-8a. See Service Adjustment Chart, Table 4-2
	3-8b. Variation of horizontal amplifier gain due to change in tube characteristics	3-8b. Change V301, V302 and/or V303; readjust SWEEP LENGTH (R317), Table 4-2
3-9. VERNIER ratios incorrect at X1, X2, or X5	3-9. Improper adjustment of CAL X1 (R232), CAL X5 (R235), or VERNIER knob is not aligned to X2	3-9. See Service Adjustment Chart, Table 4-2
3-10. Error in writing rate noted on one or more portions of the screen	3-10a. Non-linear sweep; check as follows: (1) Saw regulator (E202) voltage too high (2) Series dropping resistor (R225) out of tolerance (3) Defective V204	3-10a. Replace the following: (1) E202 (2) R225 (3) V204
	3-10b. Non-linear horizontal amplifier; check (1) Unbalanced deflection amplifier (V303) (2) X BIAS ADJ (R318) improperly set (3) Improper supply voltages applied to the horizontal amplifier.	3-10b. Replace or adjust (1) V303 (2) See Service Adjustment Chart, Table 4-2 (3) See voltage and resistance Tables; check out the low-voltage supply per schematic
	3-10c. Non-linear cathode-ray tube (V401)	3-10c. Replace V401
3-11. Loss of sync	3-11a. Sync phase splitter (V201-A) and amplifier (V201-B) defective	3-11a. Check and replace. Check tube pin voltages and resistances per voltage and resistance Tables
	3-11b. SYNC SELECTOR switch is not in the proper position for the desired mode of operation	3-11b. (1) Set SYNC SELECTOR switch to INTernal when X VOLTS FULL SCALE switch is set to either DRIVen or RECurrent SWEEP (2) External sync signals may be employed if SYNC SELECTOR is set to EXTernal (3) If line frequency excitation is employed, SYNC SELECTOR should be set to LINE
	3-11c. Shunting resistor (R208) across V202-B open (RECurrent SWEEP only)	3-11c. Check R208 and replace

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
SWEEP AND SYNC CIRCUITRY		
3-12. Undesired intensity modulation of trace noted when X VOLTS FULL SCALE is set for external signals	3-12. SYNC AMPLITUDE not set to "0"	3-12. Set to "0." This "Symptom" is a "feature" which can be used if desired; see paragraph entitled "Gated Beam Operation," in Section 2, Operation
3-13. No sweep; X VOLTS FULL SCALE set to DRIVen SWEEP	3-13. Inadequate amplitude of sync initiation signal	3-13. Adjust SYNC AMPLITUDE control for the proper phase and amplitude of the synchronization signal. Refer to Table 1-1 for information on sync sensitivities
3-14. Driven sweep does not cutoff when SYNC AMPLITUDE is set to "0"	3-14. MODE service adjustment (R213) improperly set	3-14. See Service Adjustment Chart, Table 4-2
VERTICAL DEFLECTION AMPLIFIER		
4-1. No calibration pattern when Y CAL switch is pushed in	4-1a. Defective calibrator circuitry	4-1a. See 1-12
	4-1b. Defective vertical amplifier	4-1b. (1) To check, short together the plates of V103. If trace returns to center, one or more vertical amplifier stages are defective (2) Try the one-at-a-time method of replacing the following tubes Vertical deflection dc amplifier, V103 Interstage dc amplifier, V102 Vertical input dc amplifier, V101 NOTE: The original tube should be restored to its socket if not found to be defective (3) A check of voltage and resistance may reveal other defective component(s)
4-2. Y VOLTS FULL SCALE at OFF, CRT trace shifts (up and down) with changes in setting of (Y) AMPLITUDE	4-12. Y D-C BAL (R110) improperly adjusted	4-2. See "Y DC BAL Adjustment" procedure in Section 2, Operation If satisfactory balance cannot be achieved, replace V101. This tube is preselected and may prove critical in replacement. The Du Mont Instrument Service Department can supply this selected tube
4-3. No vertical signal when Y VOLTS FULL SCALE switch is set to A-C; signal is present when switch is set to D-C	4-3a. Open input coupling capacitor (C101)	4-3a. Replace
	4-3b. Defective Y VOLTS FULL SCALE switch	4-3b. Check switch section S101-2R
4-4. Power-line frequency ripple on trace	4-4. HUM BAL (R603) improperly set	4-4. See Service Adjustment Chart, Table 4-2

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
VERTICAL DEFLECTION AMPLIFIER		
4-5. A 1 kc square wave is distorted at any one range of the Y VOLTS FULL SCALE switch (AC or DC)	4-5. Improper adjustment in the associated Y VOLTS FULL SCALE compensation capacitor and/or Y BIAS ADJUST (R118)	4-5. See Service Adjustment Chart, Table 4-2
4-6. Error in amplitude calibration noted on one or more portions of the screen	4-6a. Non-linear vertical amplifier; check: (1) Unbalanced deflection amplifier (V101) (2) Y BIAS ADJUST (R-118) improperly set (3) Improper supply voltages applied to the vertical amplifier 4-6b. Non-linear cathode-ray tube (V401)	4-6a. Replace or adjust (1) V101 (2) See Service Adjustment Chart, Table 4-2 (3) See voltage and resistance Tables; check out the low-voltage supply per schematic 4-6b. Replace V401
PRINTED WIRING		
5-1. Intermittent or jumpy trace—with or without signal input	5-1a. Defective tube-to-socket contact or corrosion of tube pins	5-1a. Check and clean
	5-1b. High resistant solder joint between a component and the PW (printed wiring) Note: This is usually found between pin, tube socket clip, and/or printed wire island	5-1b. To pin point a component that might be loose in a PW hole, pull gently on component leads with a long nose pliers. Continuity or voltage check may reveal faulty connections NOTE: The faulty joint(s) should be hand soldered. It is recommended that a 100- or 125-watt soldering iron with a large tip, sharpened to a point, be used. Thus, when the pointed tip is inserted in the PW hole to be resoldered, a good repair can be made. Never place the soldering iron directly on a PW lead. Solder should always be applied at the PW hole connection and flowed to the PW lead
	5-1c. Faulty or broken component lead	5-1c. Replace component; the proper replacement procedure is as follows: (1) To remove a component from a PW hole connection, apply heat to the top side of the board at the point of component insertion (2) Allow the iron to rest against the component lead entering the PW hole and on the PW pad around the hole (3) Maintain the iron on the PW pad until the component lead is withdrawn and completely free of PW hole. This step minimizes any tendency of the printed wiring to be lifted from the board when scraped by the component lead as it is withdrawn (4) When inserting new component, heat is applied at same point; see (1)

TABLE 4-3. TROUBLE SHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
	PRINTED WIRING	
		(5) When the solder within the PW hole has melted, the component lead will slide in easily (Alternate Procedure)
		(6) A tooth pick inserted in the PW pin immediately following removal of the component lead will displace the solder and leave the pin clear of solder for insertion of the lead of the new component
	5-1d. Damaged PW conductor lead	5-1d. Replace damaged PW lead with a bare lead following original path; if the break is not too large, a solder bridge may be employed. It is recommended that a soldering iron not in excess of 100 watts be used to make this repair

TABLE 4-4
ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED (See Table 4-2)
V101 & V102	12AU7 (yellow tipped)	Y BIAS ADJUST (R118)
V103	6BK7-A	NONE
V201	12AX7	NONE
V202 & V203	6U8	MODE (R213)
V204	12AT7	MODE (R213), CAL X1 (R232) & CAL X5 (R235)
V301 & V302	12AU7 (yellow tipped)	X BIAS ADJUST (R318) SWEEP LENGTH (R317)
V303	6BK7-A	X BIAS ADJUST (R318) & SWEEP LENGTH (R317)
V401	5ADP—	ASTIG (R412)
V402	12AU7	NONE
V501	6AQ5	If high voltage was functioning properly prior to tube failure, no adjustment should be required. If not, adjust H.V. ADJ (R509) for —1300V between ground and CCW end of INTENSITY potentiometer (R413)
V502	1X2-A	
V503	5642	
V504	6U8	
V601	5V4-G	MODE (R213), CAL X1 (R232) & CAL X5 (R235)
V602	0A2	MODE (R213), CAL X1 (R232) & CAL X5 (R235)
V603	6AL5	Check X CAL ADJ (R614) and Y CAL ADJ (R612) against a **known standard.** If no standard is available, R612 and R614 should **not** be touched

TABLE 4-5 VOLTAGE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
					SYNC AND SWEEP CIRCUITS					
		NOTES: 1. *Measure with meter of 20-megohm impedence (Simpson 260 on 1000-volt scale) or electronic voltmeter 2. Rotate MODE (service adjustment R213) fully CW to disable the gate generator (V202-A & V203-A) when taking voltage measurements of this circuit 3. Tube socket voltage variations are indicated as follows: (c) Varies with SYNC AMPLITUDE control setting (d) Varies with VERNIER control setting								
V201	12AX7	140	3.4	6.6			70	(c) 0	0	
							6.3 AC			
V202	6U8	70	54	152	6.3 AC		117	58	117	70
V203	6U8	410	48	152	6.3 AC		151	58	152	151
V204	12AT7	(d) 152*	152	152			410	(d) 152*	156	
							6.3 AC			
					REGULATED HIGH-VOLTAGE SUPPLY					
		WARNING HIGH VOLTAGES (—1300 & — 1800 VOLTS) EXIST IN THIS INSTRUMENT. USE AN INSULATED TEST PROBE.								
		NOTES: 1. Voltage measurements of V502 & V503 should be made with rf supply in its shield 2. —1300-volt supply can be measured at the CCW end of the INTENSITY control 3. —1300-volt supply should be adjusted with the INTENSITY control in the fully CCW position 4. — 1800-volt supply can be measured at the intensifier terminal of the CRT 5. † Varies with INTENSITY control setting								
V501	6AQ5	—119	0	6.3 AC			390	130	—119	
V502	1X2-A	DO NOT MEASURE—See Note 2								
V503	5642	DO NOT MEASURE—See Note 4								
V504	6U8	135 to 185 †	—5	152	6.3 AC		25 to 70 †	0	30 to 65 †	25 to 70 †

TABLE 4-5 VOLTAGE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
BEAM GATE										
WARNING USE EXTREME CAUTION WHEN MAKING THESE VOLTAGE MEASUREMENTS. NEGATIVE HIGH VOLTAGE (—1300 VOLTS) EXISTS BETWEEN ALL POINTS AND CHASSIS										
NOTES: 1. V402 voltage measurements taken with respect to —1300-volt supply (CCW end of INTENSITY control) 2. Heater of V402 is operated at —1300 volts with respect to chassis 3. V402 voltage measurements taken with INTENSITY control set fully CW (maximum intensity)										
V402	12AU7	86	76	82			84	76	82	
							6.3 AC			
LOW-VOLTAGE SUPPLY AND CALIBRATOR CIRCUITS										
NOTES: 1. Socket terminal used as a tie point for calibrator circuitry: calibrator signal measures 150 volts peak-to-peak at this point 2. Same as 1 above except calibrator signal measures 1 volt peak-to-peak										
V601	5V4-G		420	410AC	410AC		410AC	Note 1	420	
						5 AC				
V602	0A2		0	Note 2	0	150	Note 2	0		
V603	6AL5	Note 1	Note 1		6.3 AC	150	0	0		
CATHODE-RAY TUBE										
WARNING HIGH VOLTAGE (3000 VOLTS)										
NOTES: 1. V401 voltage measurements with respect to —1300-volt supply (CCW end of INTENSITY control) 2. CRT heater is operated at —1300 volts with respect to chassis 3. Voltage measured at pin 3 of V401 varies with INTENSITY control setting; at pin 9, with INTENSITY & FOCUS control settings										

SYMBOL	TYPE	1	2	3	5	7	THRU	11	14	CAP
V401	5ADP—		12.6	12 to 98	290 to 740		1560			3000
					6.3 AC					

TABLE 4-6
RESISTANCE MEASUREMENTS

NOTES: 1. Preset front-panel controls according to the chart at the head of Table 4-5
2. All resistance measurements taken from tube socket to chassis, except as otherwise shown
3. K = 1000 ohms; M = megohm

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
VERTICAL OR HORIZONTAL DEFLECTION AMPLIFIERS Vertical amplifier tube reference symbols are the 100 series; for the horizontal amplifier, the 300 series										
V101 or V301	12AU7 Yellow Tipped	110K	220K	1.2K	30K	30K	110K	220K	1.2K	30K
V102 or V302	12AU7 Yellow Tipped	150K	110K	12K	30K	30K	150K	110K	12K	30K
V103 or V303	6BK7-A	85K	150K	20K	30K	30K	85K	150K	20K	0
SYNC AND SWEEP CIRCUITS										
V201	12AX7	55K	2.2M	10K	30K	30K	100K	50K	0	30K
V202	6U8	100K	210K	45K	30K	30K	50K	12K	50K	100K
V203	6U8	50K	600K	45K	30K	30K	55K	12K	67K	54K
V204	12AT7	550K to 5M	70K	45K	30K	30K	55K	550K to 5M	25K	30K
BEAM GATE V402 resistance measurements taken with respect to −1300-volt supply (CCW end of INTENSITY control)										
V402	12AU7	360K	180K	27K	0.3	0.3	360K	140K	27K	0
REGULATED HIGH-VOLTAGE SUPPLY NOTES: 1. V502 plate cap measures 3 meghoms 2. V503 plate cap measures 45 ohms										
V501	6AQ5	150K	0	30K	30K	47K	62K	150K		
V502	1X2-A				45				45	
V503	5642	See Schematic for Checking Continuity								
V504	6U8	66K	3M	45K	30K	30K	520K	0	5.6K	520K

TABLE 4-6 RESISTANCE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
LOW-VOLTAGE SUPPLY AND CALIBRATOR CIRCUIT										
V601	5V4-G		55K	22	30		22	150K	55K	
V602	0A2	45K	0	0 to 10K	0	45K	0 to 10K	0		
V603	6AL5	160K	160K	30K	30K	45K	0	0		
CATHODE-RAY TUBE V401 resistance measurements taken with respect to 1300-volt supply (CCW end of INTENSITY control)										
SYMBOL	**TYPE**	**1**	**2**	**3**	**5**	**7**	**Thru**	**11**	**14**	**CAP**
V401	5ADP—	0	5M	380K to 620K	2 M to 5 2 M		3 2M		0	61M

COMPONENT PARTS LIST
TYPES 401 AND 401-R

CAPACITORS

(All capacitors are fixed, mica, ±10%, 500 V unless otherwise specified)

Symbol	Part Number	Description
C101	0312 8220	paper, 0.1 µf, ±20%, 600 V
C102	0302 0480	270 µµf
C103	0302 9430	820 µµf
C104	0303 3650	8200 µµf, 300 V
C105 to C107	0316 9631	variable, glass, 1-12 µµf, 600 V
C108 & C109	0301 9650	ceramic, 0.01 µf, +80 −20%, 450 V
C111	0315 2490	composition, 2.2 µµf, ±20%
C113	0315 2480	composition, 1.5 µµf, ±20%
C115	0302 0820	24 µµf, ±5%
C201	0313 8630	electrolytic, 25 µf, +100 −10%, 150 V
C202	0300 4170	paper, 0.05 µf, +20 −10%
C203 & C204	0314 0400	paper, 0.47 µf, +20%, 200 V
C205	0315 2510	composition, 4.7 µµf, ±20%
C207	0302 0390	47 µµf
C208	0301 9650	ceramic, 0.01 µf, +80 −20%, 450 V
C209	0302 0330	15 µµf
C210	0300 3070	variable, ceramic, 4-30 µµf, 500 V
C211	0326 0620	350 µµf, ±1%, 300 V
C212	0316 1570	1950 µµf, ±1%
C213	0326 0700	0.008 µµf, ±1%, 300 V
C214	0326 0610	0.04 µf, ±1%, 300 V
C215	0312 5681	paper, 0.2 µf, ±1%, 200 V
C216	0301 9650	ceramic, 0.01 µf, +80 −20%, 450 V
C217	0302 0430	100 µµf
C301	0312 8220	paper, 0.1 µf, ±20%, 600 V
C302	0302 0480	270 µµf
C303	0302 9430	820 µµf
C304	0303 3650	8200 µµf, 300 V
C305 to C307	0316 9631	variable, glass, 1-12 µµf, 600 V
C308 & C309	0301 9650	ceramic, 0.01 µf, +80 −20%, 450 V
C311	0315 2490	composition, 2.2 µµf, ±20%
C313	0315 2480	composition, 1.5 µµf, ±20%
C315	0302 0820	24 µµf, ±5%
C401	0316 8650	ceramic, 22 µµf, 2000 V
C402	0316 4930	ceramic, 0.01 µf, +100 −0%, 2000 V
C404 & C405	0319 9650	ceramic, 0.01 µf, +80 −20%, 450 V
C501	0316 4930	ceramic, 0.01 µf, +100 −0%, 2000 V
C503	0314 6090	ceramic, 1.5 µµf, ±0.5 µµf, 5000 V
C504	0314 1120	paper, 0.1 µf, ±20%, 400 V
C505	0316 4930	ceramic, 0.01 µf, +100 −0%, 2000 V
C601 A,B,C	0312 6030	electroyltic, 40/80/20 µf, +50 −10%, 450 V
C602	2000 9891	paper, 0.85 µf, 850 V (matched to T601)
C603	0318 8630	electrolytic, 25 µf, +100 −10%, 150 V
C604 & C605	0314 0360	paper, 0.1 µf, ±20%, 200 V

Symbol	Part Number	Description
NEON REGULATORS		
E101 & E102	1200 7161	ST2-32-1
E401 & E402	1200 7161	ST2-32-1
FUSES		
F601	1100 0880	15/100 ampere, slow blow
F603	1100 0820	8 amperes, slow blow
F604	1100 0780	2 amperes
LAMPS		
I601 to I605	1200 1310	incandescent, bayonet, 150 ma, 6.3 V
FEMALE CONNECTORS		
J101 to J103	5101 2551	binding post
J201 & J202	5101 2551	binding post
J301 to J303	5101 2551	binding post
INDUCTORS		
L501	2100 3810	9100 mh
L601	2100 4301	10 h

RESISTORS

(All resistors are in ohms; K=thousand, M=million. All resistors are fixed, composition, ±10%, ½ W unless otherwise specified)

R101	0221 8450	film, 2M, ±1%
R102	0221 8440	film, 250K, ±1%
R103	0221 8430	film, 20.4K, ±1%
R104	0221 8420	film, 2K, ±1%
R105	0221 8450	film, 2M, ±1%
R106	0204 1270	2M, ±5%
R107 & R108	0203 2560	220K, ±20%
R109	0225 0490	1.1K, ±5%
R110	0101 1450	variable, 250, ±20%
R111 & R112	0225 2020	120K
R114	0106 9600	variable, 25K, ±20% (part of switch assembly S101)
R115	0225 1780	1.2K
R118	0106 6150	variable, 5K, 20%
R119	0225 1880	8.2K
R120	0101 1410	variable, 500, ±20%
R121 & R122	0225 5010	100K, 1 W
R123	0225 6790	20K, ±5%, 2 W
R126	0225 7950	33K, 2 W
R127	0225 3730	11K, ±5%, 1 W
R132	0225 7930	22K, 2 W
R201	0225 1900	12K
R202	0225 2170	2.2M
R203	0225 1880	8.2K
R204	0225 1800	1.8K
R205	0225 1890	10K
R206	0101 4200	variable, 200K, ±20%
R207	0225 2020	120K
R208	0225 2000	82K

Symbol	Part Number	Description
R209	0225 7850	4.7K, 2 W
R210	0225 2140	1.2M
R211	0225 2130	1M
R212	0225 4900	12K, 1 W
R213	0106 7900	variable, 10K, ±20%, 2 W
R214	0225 2130	1M
R215	0225 2140	1.2M
R216	0225 7850	4.7K, 2 W
R217	0225 4980	56K, 1 W
R218	0225 1840	3.9K
R219	0225 2070	330K
R220	0225 2050	220K
R221	0225 2090	470K
R222	0101 3850	variable, 25K, ±20%
R223	0106 4910	variable, 5M, ±20% (part of switch assembly S202)
R225	0225 8010	100K, 2 W
R226	0225 1790	1.5K
R227	0203 6730	11K, ±5%, 2 W
R228	0201 9380	wire wound, 25K, ±5%, 5 W
R229	0225 0430	620, ±5%
R230	0225 6930	75K, ±5%, 2 W
R231	0225 1850	4.7K
R232	0101 3880	variable, 200K, ±20%
R233	0225 2090	470K
R234	0204 1330	3.6M, ±5%
R235	0101 3920	variable, 2M, ±20%
R236	0225 1770	11K
R301	0221 8450	film, 2M, ±1%
R302	0221 8440	film, 250K, ±1%
R303	0221 8430	film, 20.4K ±1%
R304	0221 8420	film, 2K, ±1%
R305	0221 8450	film, 2M, ±1%
R306	0204 1270	2M, ±5%
R307 & R308	0203 2560	220K, ±20%
R309	0225 0490	1.1K, ±5%
R310	0101 1450	variable, 250, ±20%
R311 & R312	0225 2020	120K
R314	0107 3050	variable, 25K, ±20% (includes switch S301)
R315	0225 1780	1.2K
R316	0225 1840	3.9K
R317	0102 7720	variable, 2.5K, ±20%
R318	0106 6150	variable, 5K, ±20%
R319	0225 1880	8.2K
R320	0101 1410	variable, 500, ±20%
R321 & R322	0225 5010	100K, 1 W
R323	0225 6790	20K, ±5%, 2 W
R326 & R327	0225 7950	33K, 2 W
R401	0225 5100	560K
R402	0225 1030	200K, ±5%
R403	0225 2090	470K
R404 & R405	0225 2030	150K
R406	0225 2090	470K
R407	0225 2030	150K
R408	0225 2170	2.2M
R409	0225 8160	1.8M, 2 W
R410	0225 1890	10K
R411	0107 3280	variable, 5M, ±20%
R412	0106 7910	variable, 200K, ±20%, 2 W
R413	0107 3180	variable, 250K, ±20%
R414	0225 1940	27K
R415	0225 8210	4.7M, 2 W
R416	0225 2170	2.2M
R417	0225 1950	33K
R501	0210 0810	wire wound, 4.7
R502	0225 2030	150K
R503	0225 7850	4.7K, 2 W
R504	0225 2090	470K
R505	0203 8290	22M, 2 W
R506	0210 0810	wire wound, 4.7
R507	0225 8290	22M, 2 W
R508	0225 7440	10M, ±5%, 2 W
R509	0101 8410	variable, 1M, ±20%
R510	0225 1300	2.7M, ±5%
R511	0210 9360	wire wound, 20K, ±5%, 5 W
R512	0225 1980	56K
R601	0225 1960	39K
R602	0225 1940	27K
R603	0106 6090	variable, 500, ±20%
R604	0225 1930	22K
R605	0225 8130	1M, 2 W
R606	0225 1690	220
R607	0225 8070	330K, 2 W
R608	0203 4800	1.8K, 1 W
R609 & R610	0225 2120	820K
R611	0225 1890	10K
R612	0102 3900	variable, wire wound, 1.2K, ±20%, 1.5 W
R613	0225 1890	10K
R614	0102 3900	variable, wire wound, 1.2K, ±20%, 1.5 W
R615	0225 8060	270K, 2 W
R616	0231 0021	wire wound, 10K, ±5%, 10 W
R617	0107 1112	variable, wire wound, 6, 2 W (includes S601)

SWITCHES

(All rotary switches are phenolic and the angle of throw is 30° between positions unless otherwise indicated)

S101	0501 2062	rotary, 2 sections, 3 poles, 9 positions
	0501 2061	assembly, consist of S101 & R114
S102	0500 6793	push push, 2P2T
S201	0500 9662	rotary, 60°, 1 section, 1 pole, 3 positions
S202	0501 2502	rotary, 2 sections, 1 pole, 7 positions
	0501 2501	assembly, consist of S202 & R223
S301	0501 0452	rotary, 4 sections, 6 poles, 11 positions
	0501 2061	assembly, consist of S301, S303, & R314
S302	0500 6793	push push, 2P2T
S303	0107 3050	part of R314
S601	0107 1112	part of R617

TRANSFORMERS

T501	2000 7311	rf, high voltage
T601	2000 9891	power (60-cycle)
	2001 0881	power (50-cycle)

TUBES

V101 & V102	2500 0130	12AU7 (yellow dot)
V103	2500 8560	6BK7-A
V201	2500 1500	12AX7
V202 & V203	2500 7310	6U8
V204	2500 1530	12AT7
V301 & V302	2500 0130	12AU7 (yellow dot)
V303	2500 8560	6BK7-A

types 401 and 401-R component parts list

Symbol	Part Number	Description
V401*	2500 7390	5ADP1
	2500 7400	5ADP2
	2500 7420	5ADP7
	2500 7430	5ADP11
V402	2500 0130	12AU7
V501	2500 0340	6AQ5
V502	2500 6490	1X2-A
V503	2500 5740	5642
V504	2500 7310	6U8
V601	2500 0160	5V4-G
V602	2500 0300	0A2
V603	2500 0020	6AL5

* Depending on sales order

CABLE

W601	5009 3151	power, shielded, #18/2 AWG 72 inches

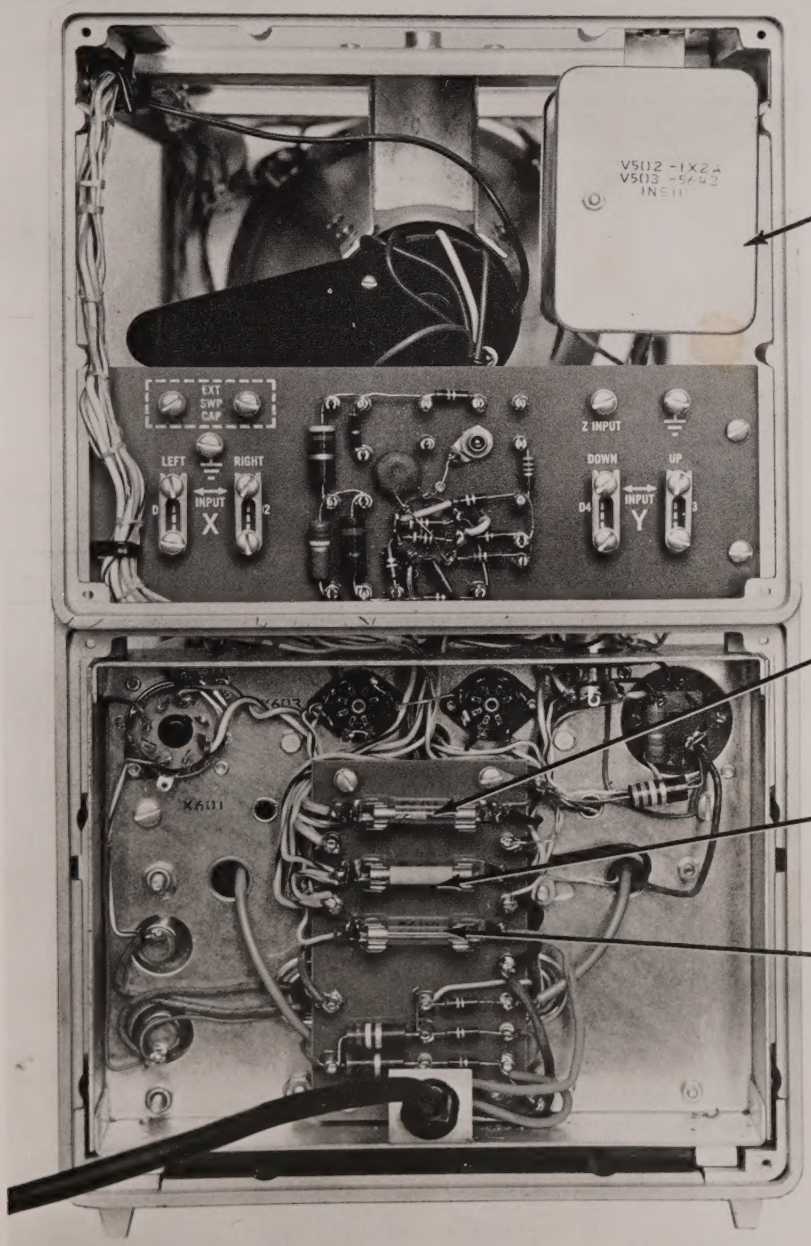


Figure 4-4. Tube and Fuse Locations, Rear View

F. T. MAINT. LAB

SMEAD'S
PRESSBOARD

COVER

No. R129

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